

NAVASSA PHOSPHATE COMPANY.

Incorporated under the Laws of the State of New York,

PURSUANT TO THE PROVISIONS OF AN ACT PASSED FEBRUARY 17, 1906,
AND THE SEVERAL ACTS IN ADDITION THERETO,
AND AMENDATORY THEREOF.

CAPITAL 30,000 SHARES.

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REPORT OF DR. G. A. LIEBIG.

BALTIMORE, Sept. 10th, 1864.

To the Corporation of the

Navassa Phosphate Company of New York :

WALTER E. LAWTON, Esq., Treasurer.

SIR :

Amongst the different fertilizers imported from distant localities for the wants of Agriculture, the divers varieties of Guano, by their powerful influence upon the crops, and the easy manner of application, have justly been kept in high estimation by the farmers, and found an extensive market.

Under this name, other substances not less beneficial to the culture of plants and cereals, have been introduced as Phosphatic Guanos—the earthy debris of birds' deposits—and for a number of years the islands in the Caribbean Sea, the Gulf of Mexico, along the coast of South America, have been the main source of supply of this article, so important for the agricultural development of our country. By furnishing to the manufacture of concentrated manures a chief material, containing a large proportion of phosphoric acid, an agent mostly derived from animal substances, and consequently of expensive origin, they were the means of restoring and exalting the fertility of exhausted and worn out lands ; have increased our agricultural products, and thus largely contributed to our general welfare.

It has been ascertained that the importation into this country of this material during the last ten years, since its first introduction—amounted to upwards of a hundred thousand (100,000) tons ; but however large this sum appears to be, it will fall into insignificance, when compared with the resources of the island of Navassa, of a valuable phosphate to the agricultural community at large and the manufacture of fertilizers in particular.

The exploration of this island could not have been made at a more propitious time, and opens a new era in the production of

fertilizers; our inability to collect a sufficiency of stable manure, and the almost exhausted state of the localities of the above named phosphates, have rendered most opportune the discovery of an immense formation of mineral phosphate for the daily increasing manufacture of fertilizers, which scarcely covers the demand.

Of the history of Navassa not much can be said, as only traces were found, to indicate that it, at one time, offered a temporary abode to some Indian tribe. In the year 1856, Captain E. K. Cooper discovered the island, and has since been in the indisputed possession of it.

Situated in 18° 25' north latitude, and 75° 5' west of Greenwich, south-west of St. Domingo and east of Jamaica, it presents itself, seen from the windward, as a perpendicular rocky mass of about three miles in length, rising some three hundred feet above the level of the sea. Its base widens to the south-west, and extends from south to north-east to a low flat level, which, almost a plain, stretches in its southern extremity about one mile out into the ocean. The whole of the island is, with little exception, covered with a luxuriant vegetation of dense woods and grass. Different species of the palm tribe, viz: Sabal Palmetto, *Arca oleracea*, etc.: several varieties of *Cactus*, some of immense sizes—vines and other climbing plants, give the whole the character of a true tropical landscape.

The island is inhabited by about forty white men, who, under the management of Captain Louis, work the place, and are provided with all the necessary accommodations.

The rock, which constitutes the island, is a hard white globuliform limestone, which, from the numerous fossils found in it, is evidently a Jurassic limestone. It is full of cliffs and fissures and interstratified with numerous layers of phosphate of lime, the out-croppings of which, on all parts of the island, make such splendid show, that even a casual observer cannot fail to disclose the fact of an almost inexhaustible deposit of this mineral. The strata and layers, the exact number of which, on account of only parts of the island being cleared of the wood, could not be ascertained, vary in thickness and their physical properties, hardness, specific gravity and color, (from the light yellow to the dark brown,) and differ consequently in their chemical constitution.

Under the lens, this mineral appears as a conglomerate of round globules of phosphate of lime, coated with a thin crust of oxide of iron and imbedded in a solid mass, which, in the darker specimens consists also of phosphate of lime.

The analysis below, made of samples of different colors, which I collected myself, will show, that this mineral, whilst it contains a uniformly high per centage of phosphoric acid, is in some parts of the island richer in phosphate of lime than in others, where the amount of phosphate of iron and alumina is larger than in the former.

The richest specimens being obtained from below the surface, demonstrate that it improves with the depth.

Again, there are some layers which have a bright rusty color, rough texture and are very friable. In these the globules are not so close together, and the mass in which they are imbedded is almost pure oxide of iron.

These exposed for thousands of years, as they undoubtedly have been, to the atmospheric action, rain, etc., became disintegrated and loose, have gradually filled the cavities of the limestone rock, and thus formed the soft deposit, with which the upper flat of the island, some one thousand acres, is covered.

From this loose mass the first shipments into the Baltimore market were made. It was introduced under the name of Navassa Guano—as such it was known, until Dr. Campbell Morpitt, in his treatise on the different Guanos, (see American Farmer, Vol. II, No. IV,) pronounced it for the first time to be a mineral phosphate. It is a more or less coarse powder, of a rusty-color, and otherwise well-known at present, as to need further description.

This deposit, of which about four to five thousand tons are dug and ready for shipment, is, as seen by the analysis, the most inferior found on the island, but, I am glad to say, it forms also the smaller portion to be worked. By a proper process, however, it can be improved, raised to 64-65 per cent. of phosphate of lime, and thus made marketable, if desired.

While speaking of this upperland, I cannot neglect to mention the existence of a number of caves there of various sizes, the bottoms of which are covered with a fine grayish looking substance, widely different in its character from the other de-

posita. It is very soft, sparingly mixed with globular grains, and yields a high amount of phosphate of lime with some magnesia phosphate. As it contains perceptible traces of nitrogenous organic matter, it seems to be of animal origin, similar to that of Mexican Guano. A sample representing a pile of twenty tons, collected in a cave of about 10' length, which I visited myself, shows almost 70 per cent. of lime-phosphate, thus proving it to be a valuable article worthy of consideration.

The lower flat land, which is by far the largest of the two, covering scarcely less than two thousand acres, is the great depot to which I wish to call your attention.

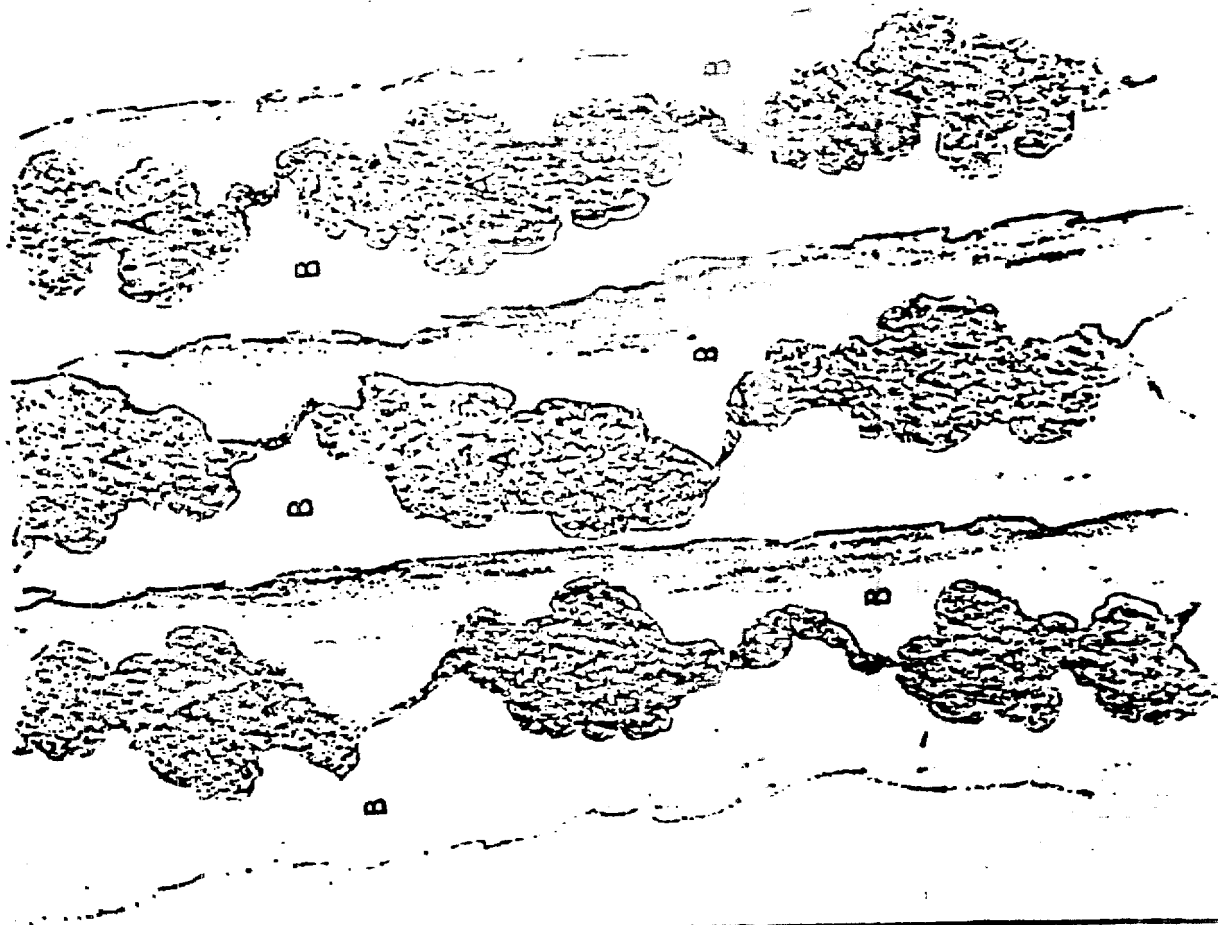
Being accessible with but little outlay of capital, and furnishing at a low calculation one thousand tons to the acre, it will constitute, independent of the rocky phosphate, for a great number of years the main source of supply for the trade.

This deposit, the product of disintegration of the richer layers, has the same globular formation, but the globules are larger, the coating is thinner and consists of alumina with some silicates. It is of light brown color and analyses from 62 to 72 per cent. of phosphate of lime, and will be a desirable material for the manufacturer.

From the peculiar formation, and the presence of free oxide of iron, it is fair to suppose that the phosphate of lime of the Navassa Island, originated from phosphate of iron and alumina, which alternating with strata of limestone, were gradually transformed into phosphate of lime. This supposition is corroborated by the large quantity of oxide of iron which is found in many places of the island, and had been set free during the process of transformation by the lime of the limestone.

I have to express here the regret, that during my exploration of the island, I did not find any crystals of this phosphate, as from my analysis I am strongly inclined to consider it a new mineral, which I should propose to call "Navassite," if my suppositions were confirmed by subsequent examinations of the chemical and crystallographic characters of more perfect specimens.

But if I have to leave for the present this question of scientific interest without solution, I am happy to record here the discovery, I may say, of an inexhaustible quantity of a mineral substance, the phosphate of lime, so instrumental in the development of agricultural wealth.



km 10

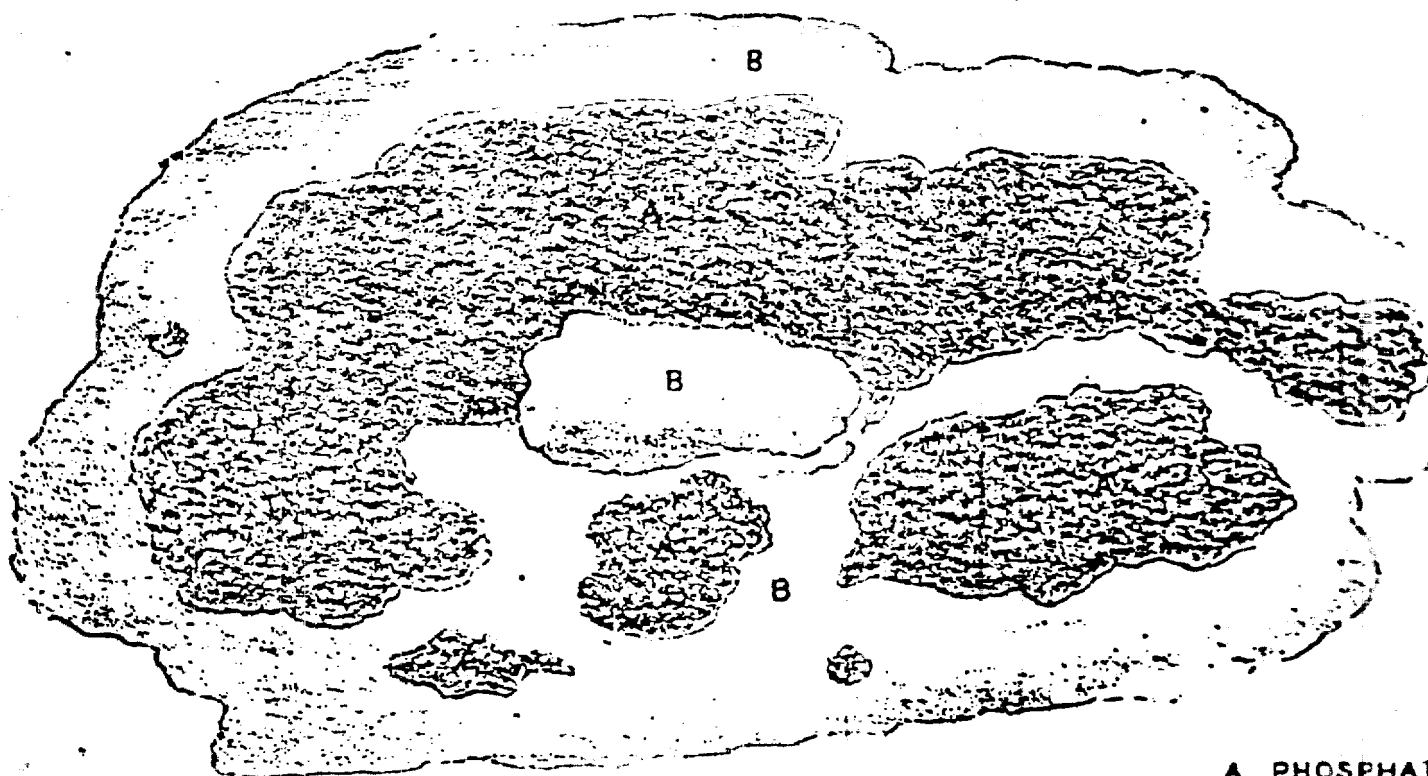
B. Limestone

MINERAL IN LIME STONE

A. Phosphate

Scale 1:10,000

W



B

B

E

A. PHOSPHATE
B. LIMESTONE

S.N. 10 feet
E.W. 6 feet

The fact that phosphoric acid is an indispensable agent to the maintenance of vegetable life and the formation of grain, becoming daily more understood by the farmer, I think it needless to dwell further on this subject, or to speak of the benefit derived from the application of phosphatic manures.

There were a variety of artificial manures introduced into the market, each of which was claimed to be the most effective one.

The enormous success, however, attained by the use of dissolved phosphate or super-phosphate of lime, attributable to the solubility of portions of its phosphoric acid, soon established the character of its superiority, and has elicited the establishment of extensive factories for this class of fertilizers.

The importance of your discovery will be readily understood, from the fact that native phosphate of lime is of rare occurrence, mainly found in Spain and some few other localities, in deposits not large enough to be the object of distant commerce. Found some years ago in the formation of crag and green sandstone of England, its extraction was expensive, and thus the manufacture of the most desirable fertilizer, the super-phosphate of lime, was wanting a source of abundant supply of the main material.

This substance, in future and for a long time to come, will be supplied to the trade to the extent of its demands, without other limits but the labor on the island and the shipping facilities.

Before closing this report, I have to insist on this most important fact, that the phosphate found on the Island of Navassa is a mineral and not a guano, although known since its introduction into this market as Navassa Guano.

From their nature, the deposits of guano are limited, and their rapid exhaustion is already felt by the consumer, but the large development of phosphate of lime—a mineral substance—found on the Island of Navassa, gives the assurance of a permanent and rich yield. As a fertilizer, the action of the ammoniacal guano is mainly due, besides to its contents of phosphates, to the proportion, or the elements it contains for the formation of ammonia. The sources for this agent are numerous, and may be supplied to the wants of agriculture by many varieties of manure, blood, flesh, fish, etc., but the case is not

this same with phosphoric acid, and from this fact, your property, the Island of Navassa, acquires a value that can hardly be exaggerated, and the working of it on the largest possible scale, will be the source of considerable and most legitimate profits.

G. A. LIEBIG.

ANALYSIS.

I. LOOSE DEPOSITS.

A. LOWER FLAT.

	Phosphate of Lime.	Phosphate of Iron and Al.	Phosph. Acid in total.
Lulu Bay.....	61.47.....	Not determined.....	Not Determined.
" ".....	62.37.....	"	30.11
East of Lulu Bay.....	72.26.....	"	30.04
" ".....	71.22.....	"	34.10
South and Southeast.....	61.46.....	"	Not Determined.
" ".....	73.05.....	"	"
East of Island.....	58.35.....	"	33.90
" ".....	63.58.....	"	33.94
North Crust.....	77.71.....	"	Not Determined.
" ".....	69.27.....	"	32.65

B. UPPER FLAT—RUST LOOKING.

Surface.....	64.77.....	5.06	Not Determined.
Fe.....	50.63.....	8.22	"
" ".....	57.11.....	6.44	"
Color contents	Gray colored.		
69.30.....	Not determined.....	Not Determined.	
68.55.....	5.55	"	

II. LAYERS AND BOULDERS.

Light Yellow Color.....	32.55.....	9.64	Not determined.
Yellow.....	56.11.....	Not Determined.....	34.53
Brown.....	71.75.....	6.11	34.41
" ".....	71.55.....	8.55	36.51
Blasted 4 feet below.....	75.66.....	Not Determined.....	Not Determined.

P. 8.—Some varieties of the native phosphate of lime react with great force the dissolving action of Sulphuric acid, thereby impeding the process of manufacture of super-phosphate of lime. I have made several experiments to that effect with the Navassa-phosphate, and found that it offers no difficulty in successfully converting it into super-phosphate—samples of which contained from 10 to 15.5 per cent. of soluble phosphoric acid.

G. A. LIEBIG.

REPORT

ON THE

Phosphatic Mineral of Navassa Island, N. Y.

To the Corporation of the Navassa Phosphate Co.

SIRS:

The undersigned sailed for the Island of Navassa in June last to make a minute examination of its geological formation with especial relation to the mineral phosphates found on it, and has now the pleasure of making the following report:

Geographical Position and Features of the Island

Navassa is situated in latitude 18° 25' north, and 75° 5' west of Greenwich, between the islands of Hayti on the east and Jamaica on the west, in the channel called the "Windward Passage," and distant from New York 1,300 miles.

It is 4½ miles in length from N. E. to S. W., and its greatest width 2½ miles. The north end being the narrowest point it presents the shape of a pear. It has two levels or flats—a lower one rising from 12 to 80 feet above the sea, and an upper one of 300 feet above it. The former begins about a half a mile west of the northern end, and widening more and more towards Lulu Bay, S. W., becomes beyond that point almost a perfectly level plain, covering, at a fair estimate, an area of 2,000 acres. This plain stretches around the south end, and continues on for more than a mile on the northeast side, until it is cut off by barren white limestone rocks. Near (south) Lulu Bay, a limestone reef traverses the lower flat, thus dividing it in two. The more southern one contains by far the greatest number of acres.

The upper flat is divided by reefs, or rather elevated limestone strata, (resembling, on account of their sharp pointed and perforated structure, coral reefs,) into several level fields, as can be seen by the Map B, representing the surface of the

island. It covers 1,000 acres, of which about forty have been worked, yielding from forty to forty-five thousand tons of phosphate of lime.

The water close to the shore is very bold, twelve fathoms deep, excepting a point near the western extremity, where a coral reef shoots out to the westward about one hundred and fifty feet, on which the depth of water is but twenty-seven feet, with fifteen fathoms all around it. The greater part of Navassa is densely wooded by palm trees and shrubbery common to the tropics. Large flocks of sea birds of various kinds roost on the trees of the lower part of the island, but their excrements are hardly perceptible. The climate is perfectly healthy; sea breezes moderate the tropical heat, so that even white labor can be employed without injury to health.

The only unfavorable feature of Navassa is the entire absence of springs. All the water necessary is either obtained from rains saved in cisterns, or has to be obtained from the near islands or the States.

Geological Formation.

The great progress made of late years in the science of geology, has made us so well acquainted with all the rock formations, that it is now a comparatively easy matter to determine and classify the different strata and place them where they belong.

Among the many petrified shells covering the joints of the limestone, the best preserved are *Pecten Personatus*, (the inner side of them,) *Gryphaea Virgula* and *Ammonites Striatulus*, in every respect like those so frequently met with in the Jura system of Europe. The limestone of Navassa belongs therefore to the secondary formation. It is of white color, has an uneven, rough fracture, enclosing some round grains (oolites) and apparently a great many small shells that cannot now be classed.

This island was, at the time of its origin, under the level of the sea, where the strata were successively deposited in a more or less horizontal position. After a stratum of the compact limestone had been formed, layers of phosphate of alumina, phosphate of lime and globular lime, alternately changing with another, settled on it, being followed again by a stratum

of the former. This process has no doubt been going on for many ages, as the great number of strata of which the island is composed demonstrate—as they stand now quite perpendicular, it is further evident that they were afterwards upheaved by plutonic power. Their strike is S. to N., possessing a thickness that varies very much. The strangest appearance in the white limestone are the round holes, from $\frac{1}{2}$ of an inch to 6 and 8 inches in diameter, produced probably from the emanation of gases. The sides of these holes, as well as those of the phosphatic beds, are covered with a crust of pure phosphate of lime, reaching a thickness of over half an inch.

The rocky kind of phosphate contains a few grains of yellow and blackish sand, but no remains of fossils of any kind are perceptible, having doubtless been destroyed by the action of the heat that existed at the time of the upheaval.

On the out-croppings of the limestone strata, the phosphatic minerals appear in nests of very irregular forms and sizes, as shown by sketch 'C'. The greater part of them widen considerably in descending, and are finally cut out. See sketch 'D'. I am, however, of opinion that, by removing the limestone intervening, similar nests will be found underneath, as it must be taken for a certainty, that the phosphate of lime running parallel with the strata of the carbonate of lime, will extend as far as the latter, a presumption partly proved, at a point right close to the level of the sea, on the N. W. side of the island, where the surf has washed away a part of the limestone and exposed a large stratum of rich phosphate, at a distance of over 250 feet from the top of the island.

On the lower flat the grayish phosphate is predominant; on the upper one the reddish brown. At innumerable places the hard undecomposed phosphate of lime crops out, from which, as well as from the fine, samples have been taken indiscriminately by Doctor Liebig, for the purpose of obtaining perfect and correct average ones.

Working of the Phosphatic Deposits

The working of the phosphate of lime since its commencement, about nine years ago, proves clearly how easily and cheap this mineral can be sent to market. Pick and shovel are the only tools needed. After the upper part, generally mixed

with many small roots and fibers to a depth of two or three inches, has been removed, the disintegrated mineral appears in form of roundish grains, wanting only to be loosened somewhat with the pick to facilitate the shoveling. Most of the openings, as stated already, increase in size, frequently to a considerable extent, a single one yielding many tons of phosphate; a circumstance that makes it very difficult to arrive at an exact estimate of the quantity of the fine phosphate contained in them. The only feasible plan was, therefore, to ascertain what area had been worked near Lulu Bay, on the lower flat. We found that from $1\frac{1}{2}$ acres, one thousand six hundred and thirty-five tons had been shipped to a house in Camden, N. J., and that there yet remained two large piles at the landing ready for shipment, containing at the lowest estimate five hundred tons, making two thousand one hundred and thirty-five tons, although it had not been worked with that care and economy which the value of it demanded.

The island possesses an area of somewhat over 11 square miles, and deducting from it one-half as occupied by carbonate of lime, it leaves $5\frac{1}{2}$ square miles which are covered with the phosphate. Taking only 5 miles into consideration, the same, according to the above statement, will yield four million five hundred and fifty-four thousand six hundred and sixty-six tons of the fine variety of phosphate. That this estimate is correct is further proved by the quantity worked out from not quite 40 acres on the upper flat, and from which forty-five thousand tons were obtained, of which about five thousand tons lay near the landing waiting shipment.

Among the fine-grained phosphate is found a great many loose lumps, and in working lower down in most of the nests, this mineral assumes a hard rocky nature.

I have stated already that the hard phosphate is visible on the surface at a great many places; should it prove by analysis to be good, then it can be said, without the least exaggeration, that this mineral is indeed inexhaustible.

The cost of digging and wheeling a ton of the disintegrated phosphate, I estimate at one dollar. This work can be lessened, and consequently made cheaper, by laying railroad tracks, the construction of which, on account of the level nature of the flats, could be put down at a small cost, especially if the rail

is laid on wooden tracks. The two shutes, from which the boats are loaded, will be sufficient for a long series of years; and as pretty near all other accommodations, such as houses for the hands, for storing provisions, for catching rain water in cisterns, are put up, the working capital need not be large.

In conclusion, I wish to remark, that the harbor of Navassa is an ordinary trade wind harbor, but being sheltered by the adjacent mountainous islands of St. Domingo and Cuba from heavy gales and seas, is much improved thereby. There are no reefs or shoals near the island that would make shipping dangerous, and vessels can haul close along side of the cliffs, if they wish to do so, as the depth of water all around the island is twelve fathoms, and the same depth for a mile or more from it, with but little variation. The facilities for loading vessels are therefore very superior. Owing to the cliffs being about forty feet perpendicular, the phosphate can be shuted down in boats and launches. One hundred tons a day are frequently put on board of one vessel with only thirty or forty men and two boats.

Taking into consideration the immense quantity of phosphate deposited on your island, the great ease for digging and loading, the short distance to a market, the giving out of the phosphatic guanoes of the Caribbean sea, the scarcity of it in nature, and the great demand, which will be almost unlimited, for the manufacture of super-phosphate, it cannot fail but that Navassa must become the main source from which this mineral can be supplied.

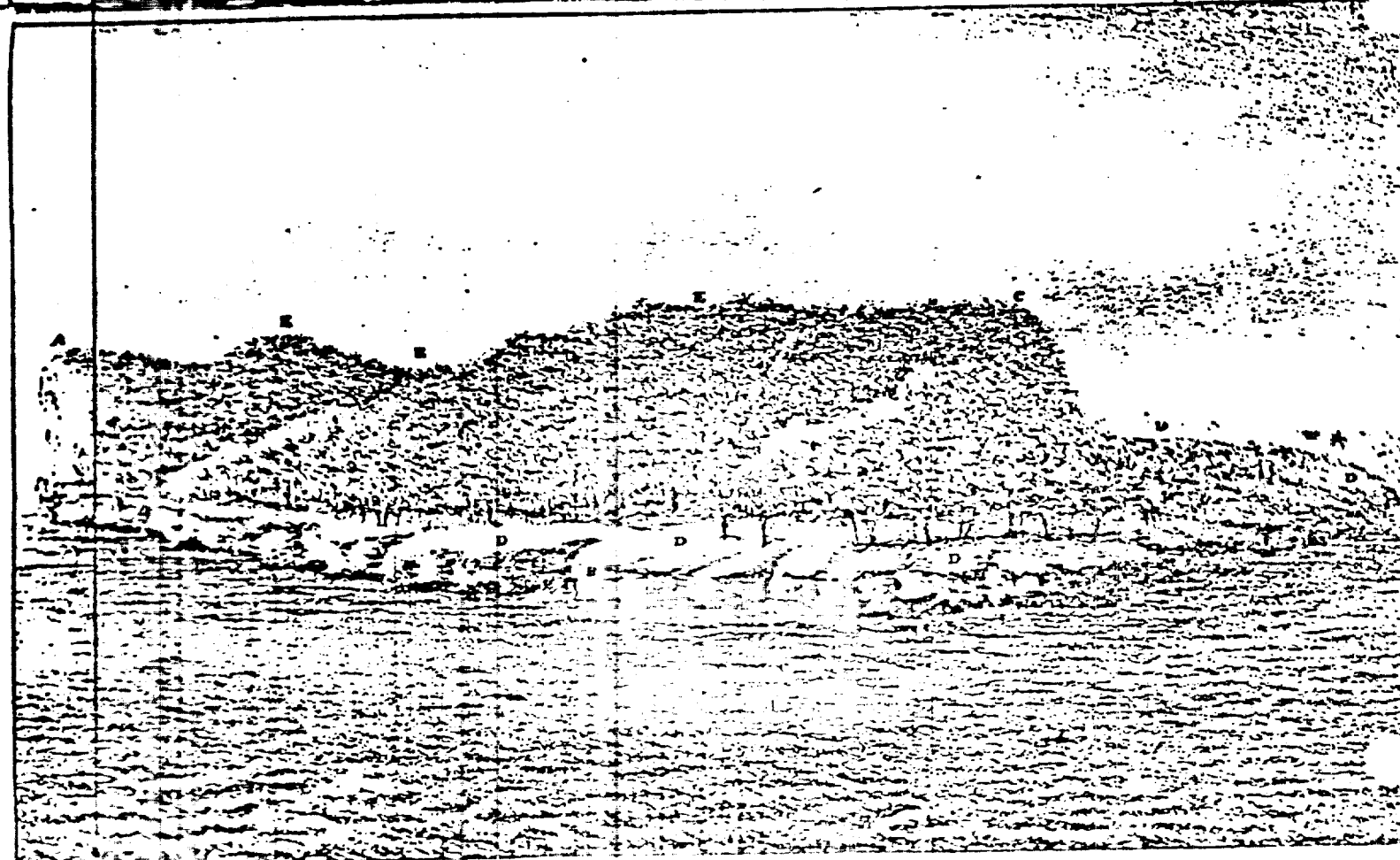
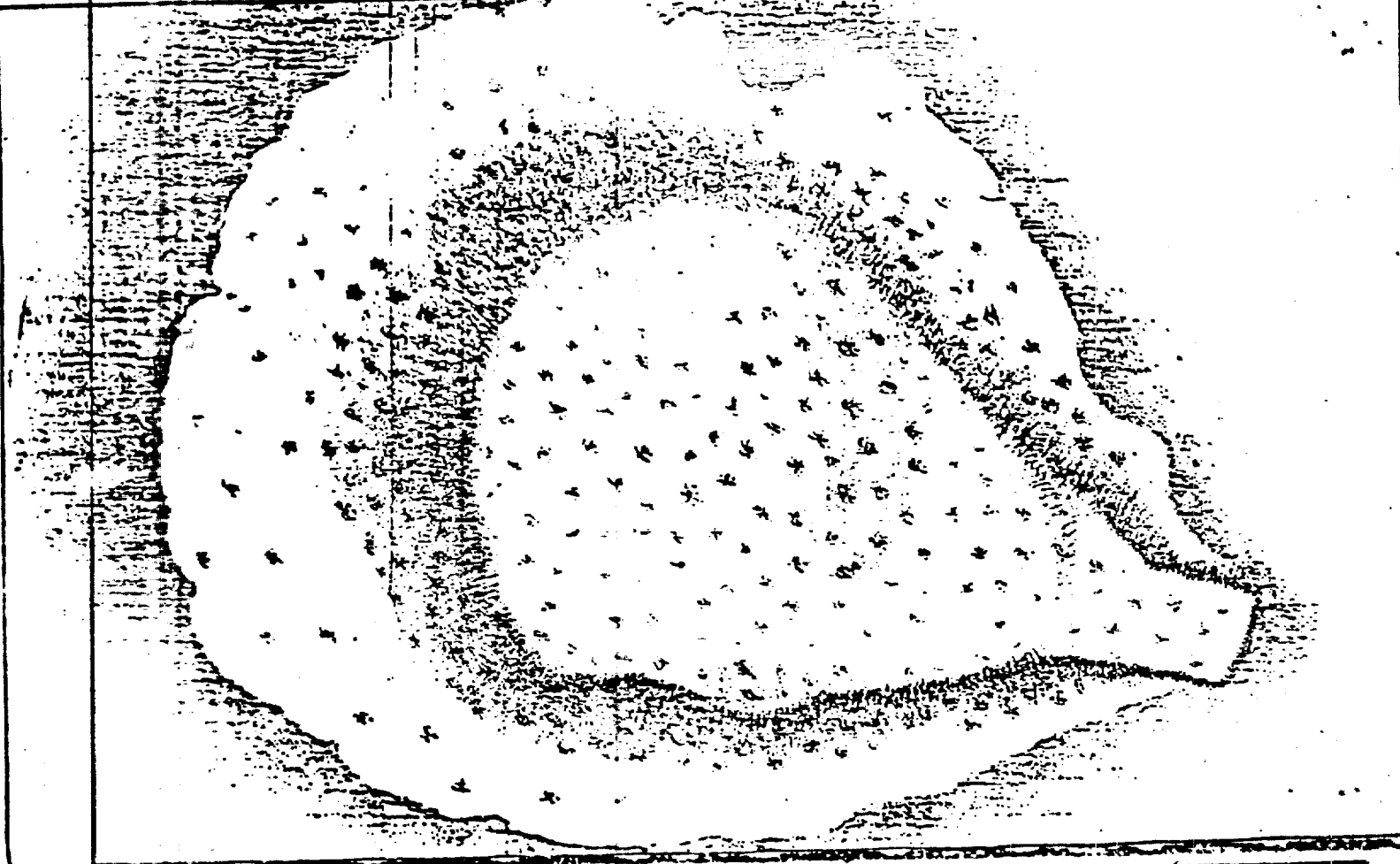
Wishing you all success,

I remain,

Very respectfully, yours,

AUGUSTUS H. FICK,

Mining Engineer.



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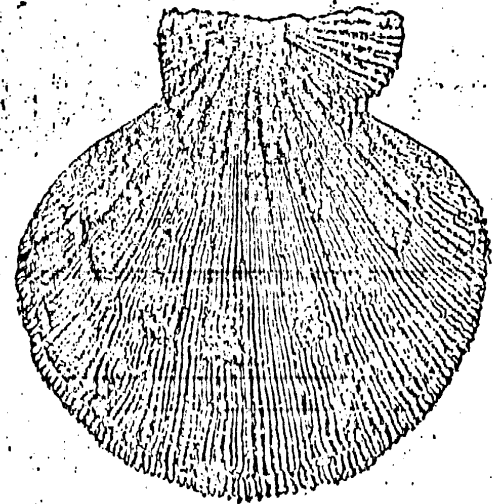
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HARVARD NAVASSA EXPEDITION

By WILLIAM J. CLENCI

A rare opportunity was offered us to visit this very small island in the Caribbean Sea during the winter of 1929-30. Little was known of its fauna and flora and we experienced some difficulty in getting even general information about the island.

The party consisted of myself, H. A. Rehder and W. E. Scheybal. We sailed from Boston on a United Fruit steamer for Antilla, Cuba, and then crossed to Cuba by train to the United States Naval Base at Guantanamo. Arrangements had been made for us to use the navy tug, the *Montcalm*, the expense to stand the cost of the fuel consumed. When we received the bill for the fuel, we were more than grateful to the Navy that they hadn't offered us battleship for the trip.

Navassa is a small rocky island, approximately 0.6 miles south of Guantanamo, Cuba, and about 30 miles west of the south of Tiburon peninsula of Florida. It is a little over one mile at greatest diameter. This island is a limestone formation and appears as an elevated sub-circular reef. It is completely honeycombed with deep holes and supports a rather scant xerophytic vegetation that is anything but easy to get through. Cactus is plentiful and more than ordinarily spinose.

In the afternoon of December 29, we steamed out of Guantanamo for a week's stay on the island. At 2:30 the following morning we sighted Navassa Light 25 miles ahead and cruised along with reduced speed, awaiting break. In the early dawn our objective appeared to be a land mass of narrow limits, rising only a short distance above the sea. In outline it resembled a gigantic straw hat with a low flat crown. Fortified with a hearty breakfast, we went on deck and found we were then only a few hundred yards from the lee side. The *Montcalm* came to a stop, our duffle was loaded into the tug's motorboat and the three of us piled over side with four sailors as crew.

By this time the rim of the "hat" had changed into rather massive rocky cliffs. On closer approach we spotted our landing place which consisted of a chain ladder running down the face of the rock. When we got very close, the anchor was cast over, and with this acting as a drag, the boat was brought up underneath the ladder. Fortunately the day was calm, but despite this the swells were running high enough to cause plenty of excitement. The boat is undercut about four feet at sea level and every moment it looked as though the boat would forge underneath the overhang and the next swell

crush her against the roof. Two sailors in the bow fended her off with oars and at opportune moments we took our turns in jumping for the ladder, literally climbing aboard the island. With the aid of a long rope we managed to pull up our supplies to the ledge above in about an hour's time. Shortly afterwards the *Montcalm* started back for Cuba and we were left alone on the island.

We camped in the patio afforded by the light house and from there made daily trips to various parts of the island. The quarters we occupied had been used by the lighthouse keepers and their families, but six months previous to our visit, the light had been made automatic and these people were moved elsewhere.

Land shells were limited to *Chondropoma navassense* Tryon, *Helicina circumlineata* Tryon and *Sagda ganssaini* Tryon. The *Chondropoma* were found in bunch grass and climbing up small trees after a rain. The *Helicina* were found under slabs of lime rock and though found wherever we searched, were huddled in numbers at any one spot. Live *Sagda* eluded us until an accidental discovery located them. A particularly attractive lizard had made its way down into a pile of loose small stones. In digging down some two or three feet for the lizard, we came upon a colony of the *Sagda*, some 500 in number clinging to each other and forming a mass of snails about the size of a fist. Three such colonies were found in the same way. This was difficult collecting as there was no indication of where such colonies could be found other than by blind search. We must have moved about two tons of rock before these three colonies were found.

Marine collecting was not easy as it was exceedingly difficult to reach the water's edge because most places on the leeward side consisted of high cliffs, generally deeply undercut at the water line. On the windward side the heavy swells of the Caribbean made any approach to the rocky water line impossible. We did manage to get down in three places on the leeward side and found the usual assemblage of West Indian rock-loving snails, *Nerita*, *Patchiparapura*, *Thais*, *Littorina* and numerous Chitons.

An interesting discovery was that *Tectarius muricatus* Linne were far larger on the windward side. Here the salt spray was carried in quantity to their area well above the high water line and consequently they were more active and fed more frequently than those on the lee side which received but little spray and were activated only by the occasional wandering rainstorms or "chubascos."

It's a "bird island" and thousands of boobies were nesting all over the place, in the small trees, on the low bushes and even among the low vegetation. A few frigate birds were also nesting and to see these beautiful birds close at hand was a royal experience.

At the end of our two weeks, the *Montcalm* appeared early in the morning and we were soon on our way back to Guantanamo. At this latter place we

PAGE SIXTY-FIVE

DE SIXTY-FOUR

...ined for another week working the shore line for much valuable material
... the several beaches and rocky headlands.

A trip of this sort is always fun. It is different and the various ex-
periences enjoyed highlight it and set it completely apart from other trips that
are carried out with the more conventional means of transportation. We had
lived in the Navy store at Guantanamo, and at the time of our visit, the
canned tomatoes they had were in gallon sizes. We had to take supplies
six weeks in case a period of rough weather made it impossible to take us
the island at the appointed time. When we opened a gallon can of toma-
toes that was our meal for three men. During this period of pinpoints and ration-
ing I became just a bit wistful and think of a gallon can of tomatoes, three
and no pinpoints.

THE REASON WHY

A wise person does not eat oysters in the months without R because then
they are spawning and flabby. But do you know that certain clams and mus-
sels in the summer may actually be deadly poisonous? A friend of this Museum
telling us of an experience in Baja, California, which almost proved fatal,
he and his camp-mates ate some seemingly delectable clams which they
had along the ocean front. Since then we have learned that the poison is due
to certain microscopic organisms of the sea, known as dinoflagellates, which
times become so abundant in summer as to give the water a reddish ap-
pearance. Although ordinarily occurring some distance from shore, they are
usually carried by currents close to the beaches and enter the digestive
systems of clams and mussels.

The poison contained in these "dinos," although not harmful to the shell-
fish itself, is highly dangerous to man. The white meat of the shellfish con-
tains the poison; it is practically all concentrated in the dark central portion
of the meat. To date, there has been no known case of shellfish poisoning where
the "dark meat" has been discarded. Therefore a safe rule is: Do not eat the
dark meat (dark meat) or drink the juice from mussels, clams or similar
fish from the open Pacific coast, between May 1 and November 1.—
J. H. S. Natural History Museum, Balboa Park, San Diego. May 1, 1944.

...ll your shell collecting friends about MOLLUSCA, we need their sup-
... too!!

E SIXTY-SIX

WHAT SHELL IS THIS?

In the files of MOLLUSCA we have many cuts, some o'd, some new of
shells. We don't know what species they are. Some of these cuts are in
excellent condition, others are worn, but are of no use unless we know the
species. Whenever photo permits we will publish one or more of these cuts,
it will be your job to identify the shell, and give the general locality and any
other facts possible concerning this shell.

We are particularly interested in securing the information for our files
so that articles may be more fully illustrated. Be sure your information is
correct.

To the person sending in the first best and most accurate identification
we will send a shell or two for their collection.



NO. 1



NO. 2

It was a source of inestimable comfort to the devoted that the people ardently responded to the Patriarch's call and by peaceful mass demonstrations of their religious sentiments largely succeeded in putting a stop to the open campaign started against the Church.

THE CHURCH PROBLEM IN THE UKRAINE

In connection with the Ukrainian separatist movement, a group of Ukrainian public men raised the question of the separation of the Church of the Ukraines from that of Russia. It was decided to summon a special Ukrainian Church Council. As Regional Councils are provided for by the organization of the Russian Church, the Moscow Sobor did not protest against the summoning of a Sobor at Kiev, and the Patriarch sent his representative to Kiev with a message of greeting.

While the civil war which broke out in Kiev interrupted the work of the Sobor, tendencies were disclosed of a more moderate character than those advocated by the supporters of a complete separation from the Russian Church.

In the midst of the trials besetting the Russian people, mainly through their own guilt, the Church proves its vitality. It is now reconstructing its outer forms, which had greatly deteriorated during the past from Orthodox Church order. But outward forms are not vital; inner life is of far greater import. That source of inner life never ran dry in the Russian Church, in spite of the numerous defects of its outward forms, for the deficiency of which it often compensated.

Let there be no misgiving; the Church has aided Russia in every crisis. The Church which even in the nineteenth century produced such shining lights as St. Seraphim of Sarov and Father John of Kronstadt, besides hosts of others, that Church is sure to foster and develop its inner life, now that better conditions of external organization are secured.

In the present moment of confusion in Russia the Church is the only institution which stands on its feet. May not the example of the Sobor well pave the way in due time for a similar triumphant reconstruction of the Russian body politic?

Dated 1918

AN IMPORTANT NEW GUIDE FOR SHIPPING

Navassa Light, on a Barren Island in the West Indies. is
the First Signal for the Panama Canal

BY GEORGE R. PUTNAM

COMMISSIONER OF LIGHTHOUSES

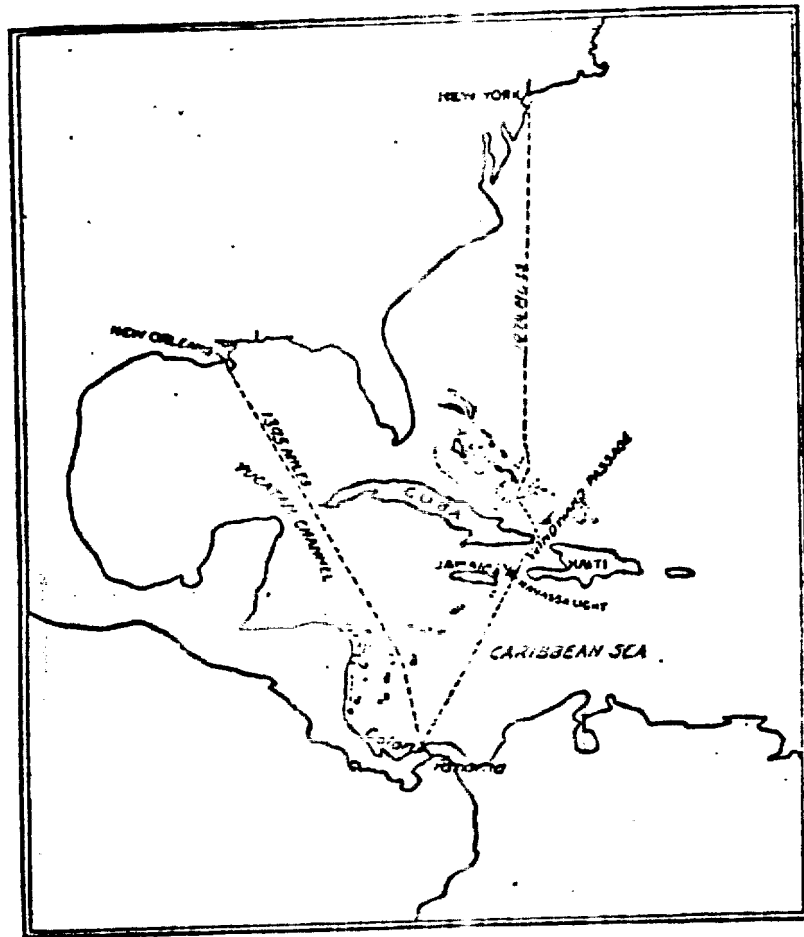
LIGHTHOUSES and other sea marks are as necessary for the safety of traffic on the sea as are signal lights for the protection of railway travel.

It is interesting to note that there are waterways which are operated much like railways. Thus portions of the Detroit and St. Marys rivers, which carry the enormous traffic between the Lakes, have practically been double-tracked by dredging and marking separate channels for up-bound and down-bound vessels, and in some narrow parts of this passage a block-system has recently been introduced, so that by means of semaphore

signals a vessel is prevented from passing until the preceding vessel has gone a safe distance. Similar systems are in use on important canals.

In normal times the shipping of the North Atlantic is operated on a double-track plan, with distinct lanes agreed upon for east-bound and west-bound vessels, and these lanes are for safety shifted to the southward during the iceberg season.

New York has a sort of four-track entrance from the sea, and of the four channels leading to the Narrows, the great Ambrose Channel is reserved for



SKETCH MAP SHOWING THE LOCATION OF NAVASSA LIGHTHOUSE AND THE UNMARKED SHOALS OF THE CARIBBEAN

Coral reefs and islets above water are shown by solid line, submerged rocks and shoals by dotted line

express and high-class traffic, and sailing vessels and tows are not permitted to use it.

WHERE OCEAN TRAFFIC LINES CONVERGE

The great increase in the shipping interests of this country and the building of the Panama Canal have attracted attention to a large area which is poorly provided with safety signals for navigation. The Caribbean Sea, once known to fame mainly by the exploits of the early buccaneers, is now a region where ocean traffic converges from north, east, and south toward the Panama Canal.

The northwestern part of this sea is strewn with rocks, coral reefs, and submerged dangers, unlighted and unmarked,

a constant menace to shipping from New Orleans and the Gulf, which must pass through lanes between the reefs, and from New York and the North Atlantic coast, which must go close to several of these dangers.

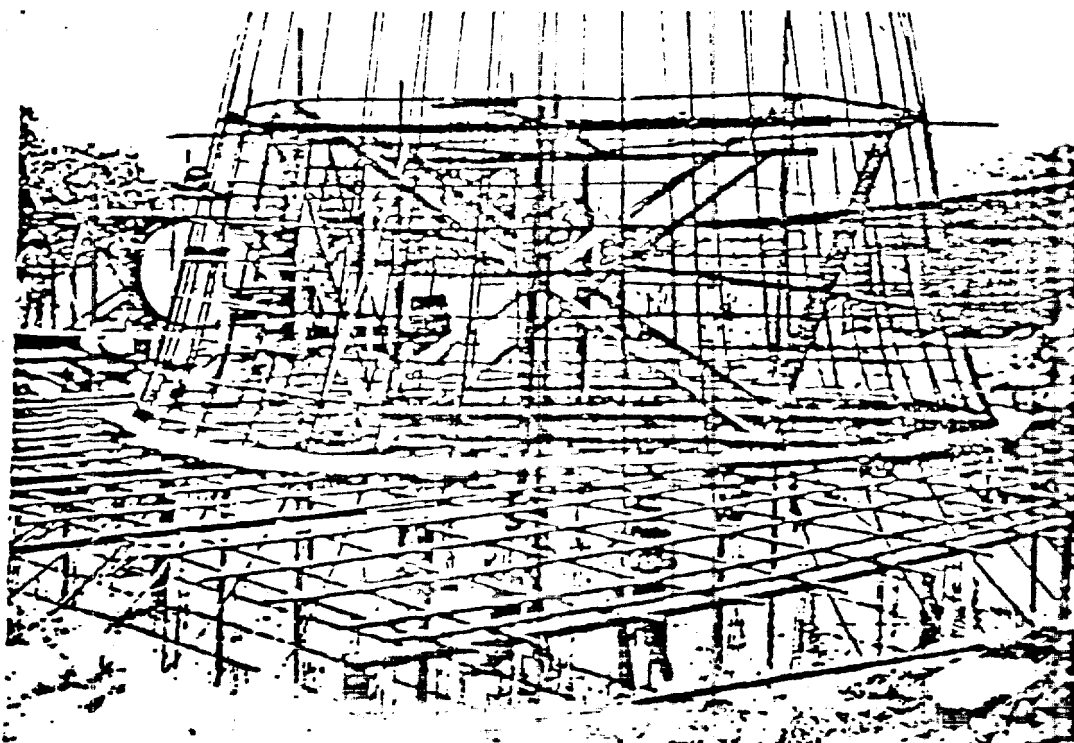
On one of these dangers, Navassa Island, 600 miles north of Colon, the first signal for the Panama Canal has recently been placed. On this barren and uninhabited rock the United States Lighthouse Service has built a lighthouse of unusual type.

The main route to the canal from our Atlantic seaboard is between Cuba and Haiti, through the Windward Passage and Navassa Island lying between Haiti and Jamaica, mark the southern approach to this passage, and is the first landfall for vessels from Panama cross-

ing the Caribbean Sea. The importance of its position with respect to shipping to and from the canal caused the United States to undertake the building of a light station of the first class on this inhospitable rock.

NEW LIGHT SWEEPS AN AREA AS LARGE AS DELAWARE

After many difficulties of construction due to the inaccessibility and character of the island, on October 21, 1917, the light was first shown from the new concrete tower. Every night since then two beams of 47,000 candlepower have swept around the horizon each 30 seconds with clocklike regularity. Instead of a dark rock, which had loomed in the night



Photograph by F. C. Hingsberg

THE BEGINNING OF THE CONSTRUCTION OF THE TALL LIGHTHOUSE, SHOWING THE STEEL REINFORCEMENT IN PLACE FOR THE FOUNDATION AND BASE OF THE TOWER

The steel skeleton, around which the concrete of the tower was poured, consists of 40 vertical steel bars, banded by a spiral of round steel bars, with loops one foot apart, wired to each vertical bar.

29
5-1
10-10
X
this passage, threatening mariners since the days of the early voyagers, these great rays now flash out friendly guidance to the seamen of all countries, regardless of nationality: the beams of this light have been seen 29 sea miles away, reaching nearly to the Haitian coast, and they sweep a sea area of about 2,200 square statute miles, as large as the State of Delaware.

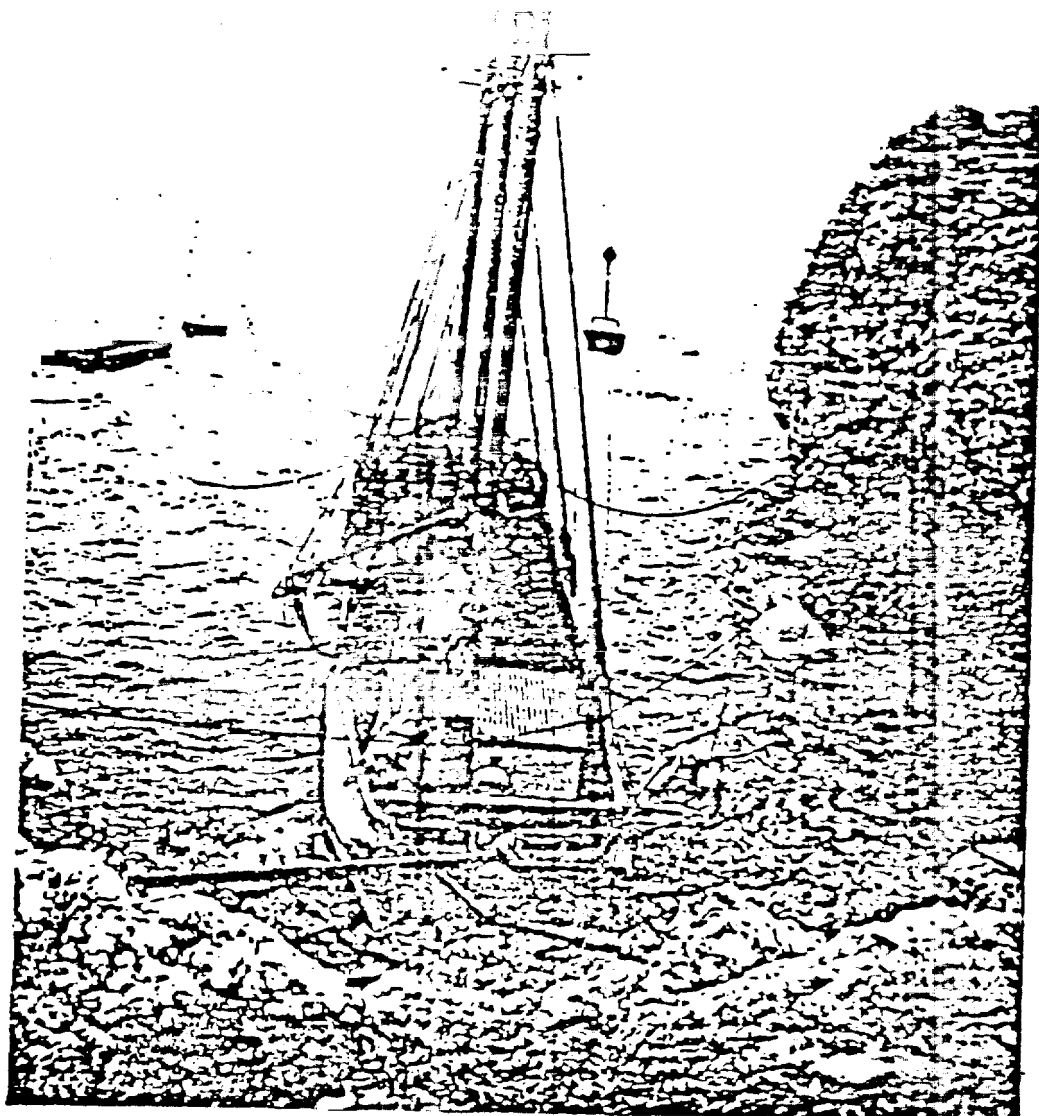
X
Navassa light, on this rock in the center of one of the principal international sea passages and 500 miles from the American coast, is the most important lighthouse built by the United States in the last quarter century.

A TOWER TO WITHSTAND HURRICANES AND EARTHQUAKES

Navassa Island has the outline of an oyster shell and is slightly more than a

mile in area. As the island rises fairly abruptly on all sides, forming a roughly flat tableland about 200 feet above the sea, it was necessary to build a tower 130 feet in height, in order that the light might "see over" the edge of the plateau and not be obscured to vessels in the vicinity of the island, unless close under the cliffs. The tower was placed on the highest part, bringing the light 395 feet above the sea.

X
The lighthouse tower was designed to withstand West India hurricanes as well as earthquakes, and the lower sections have massive proportions, the base being 25 feet in diameter, with walls over 6 feet thick. It is built of reinforced concrete, one of the tallest towers yet constructed by this method: it is of simple and dignified design, bell-shaped at the base, and above that a simple cylinder to



Photograph by Thomas Sand

NAVASSA ISLAND LIGHT STATION, WEST INDIES: SCHOONER IN LULU BAY UNLOADING SAND

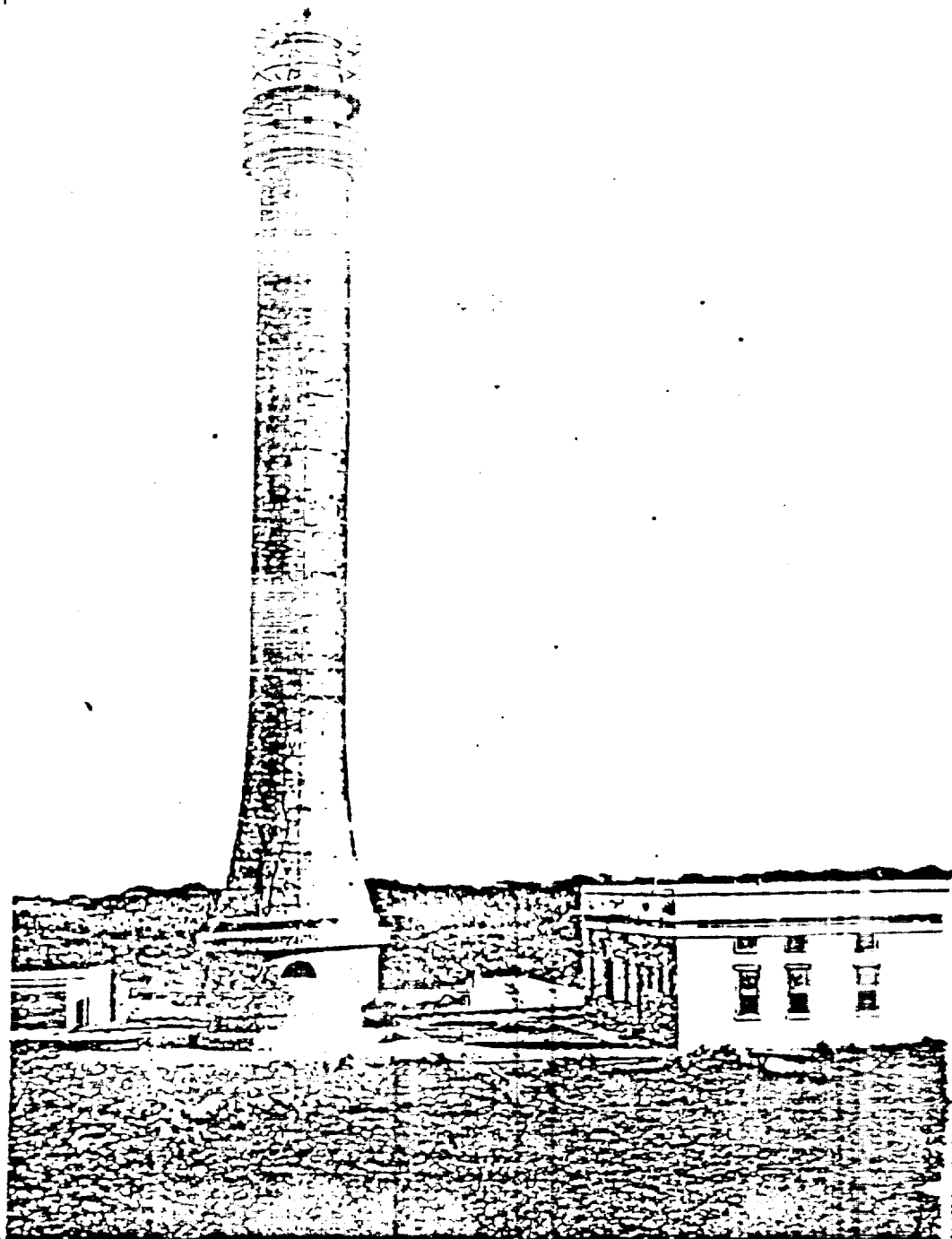
A little nook called Lulu Bay, with the schooner moored to the cliff; this is the landing place available on Navassa Island. All the supplies and material for the light construction, as well as the workmen, were brought to the island by this little schooner, which was the only means of transportation for the year and nine months that the work was in progress.

the watch-room gallery. The use of this structural material has resulted in a much more slender outline than has been necessary in masonry lighthouses.

Almost everything required for this work had to be brought from a distance; the skilled employees were sent from the United States, together with all special

supplies and equipment; the laborers came from Cuba and Jamaica, and it was even necessary to bring from Jamaica the sand and most of the water used in construction.

The nearest ports were Guantanamo, Cuba, 90 miles, and Kingston, Jamaica, 110 miles distant. No good landing



NAVASSA LIGHTHOUSE

Photograph by F. C. Hingeborg

Built by the United States Lighthouse Service, of reinforced concrete, on an uninhabited island in the West Indies. The concrete tower is 150 feet in height. The dwelling for the keepers is shown to the right.

ists on the island, so that the little schooner that was used to bring supplies and men had to be moored under the rocky cliffs, when weather favored, and the cargo hoisted onto the shelf above; this small craft had narrow escapes from hurricanes, and there were many days when it was impossible to land.

On one occasion, after being damaged in a storm, the schooner with her load of supplies put back to Jamaica, and there was apprehension as to the food on Navassa, but this reassuring report was received: "The last flour was used for making bread on Friday. There were sufficient rations on hand to last through Sunday, and with goats, wild pigeons, fish, etc., together with a pig and a number of chickens which are kept here, we were in no serious predicament."

An unusual feature in lighthouse building, a radio equipment, much facilitated construction.

Men quickly tired of the monotonous life. On account of climate and difficulty of transportation, very little fresh food was available, and the workmen persistently grumbled. The excessive heat soon diminished their efficiency. The transportation of materials from the landing place to the site was a most burdensome task, as this had to be done largely by men shoving the loaded cars on the work railway.

ISLAND RESEMBLES A PETRIFIED SPONGE

Navassa is one of the strangest pieces of territory owned by the United States. It is a remarkable formation of volcanic limestone, completely riddled with holes and pockets, some of great depth and having no visible bottom. These holes are so numerous that one can walk only with great difficulty.

There is a total absence of water, and no watercourses or lakes, as rain is immediately absorbed by the cavities. The whole island has the appearance of a great petrified sponge. There is a growth of stunted trees and underbrush on the high plateau, and the island has some animal life, wild goats and wild cats, doubtless descended from those brought here

when the island was occupied, and numerous seabirds and land-crabs.

UNITED STATES' TITLE TO ISLAND RESTS ON MURDER-TRIAL DECISION

It is a curious fact that the title of the United States to Navassa Island rests on the decision in a murder trial. Although uninhabited and long abandoned at the time the lighthouse work was undertaken, Navassa was for some years actively occupied. The pockets and surface of the island contained a large deposit of a phosphate earth and guano.

Under the guano act of 1856, one Peter Duncan presented a memorial to the Secretary of State stating "that on the first day of July, in the year of 1857, he did discover a deposit of guano on an island or key in the Caribbean Sea not occupied by the citizens of any other government, and that he did take peaceable possession of and occupy said island or key of Navassa in the name of the United States." These deposits were worked by a company for a number of years, up to 1898, and the ruins indicate an elaborate plant for this purpose.

In 1889 about 150 men were employed on the island, and on September 11 of that year a riot occurred, in which the superintendent and several of his assistants were killed. The frigate *Kearsarge* took the murderers off the island and they were tried in Baltimore.

The defense set up the plea that the island was not an American possession and that the court had no jurisdiction, but the Supreme Court denied this plea and the murderers were executed.

A concrete dwelling, in the Spanish style, with a large open patio in the center, furnishes comfortable quarters for the families of the three keepers who carefully watch this, one of the loneliest of the sea signals of this country. They see many a passing ship, but can expect supplies and mail only when the supply steamer visits the island, a few times a year.

The matter of marking other dangerous reefs of the Caribbean Sea for the protection of the increased shipping is now receiving special consideration.

were with them.

July 2

We traveled all day but failed to reach the highest settlement.

July 3

We reached a couple of huts where we left the mule, and hired a couple of natives to carry outfit up the steep trail which had such an incline that the interpreter was unable to carry anything. After locating in a little hut which was used by the natives when they were clearing new land, I went to the top of the ridge and cut a trail in the afternoon. It rained heavily and I returned to camp about 5 o'clock.

July 4

Up with two natives to cut the trail. They were too slow so I cut most of the time nearly to the peak. Birds were scarce and the cutting bad. I saw no different birds so started to return. On the return trip for two miles I called often but did not get a shot.

July 5

I looked about on the ridge and went along on a pine ridge, but found nothing except a couple of the new Yellow-spots to collect.

July 6

Back to Port à Pitant by a much better trail and found the botanist still on his back.

July 7

I returned to Aux Cayes.

July 12

Start for Navassa Island with schooner 'Express' bound for Santiago, Cuba, with thirty-five Haitian laborers.

July 15

Saw a large Shearwater, or possibly two, at a distance. Bright white below, and dark blackish above. Both were seen from behind a good ways off.

Reached Navasca at 4 P. M., and went ashore in a rough sea. I found Mr. [redacted] in charge of the lighthouse construction, and arranged to stay with him till his schooner, due tomorrow, leaves.

July 14

I went over a good part of the island and found the White-crowned Pigeon and Ground Dove, and Vireos, the only land birds. Red-footed Boobies were common all over the island but not nesting. A few Frigate Birds were sitting around in spots. A few Noddy and two Sooty (?) Terns were along the coast with small colonies of the common Booby. I found a Pigeon's nest in a green tree eighteen feet from the ground; it was composed of a few twigs and contained a fresh egg. Pigeons were cooing everywhere. Very few Ground Doves and Vireos were seen, and those only in the western part near the lighthouse.

July 19

Started for Guantanamo in the contractor's schooner.

July 30

Santiago

Been waiting two weeks or so for instructions, and leaving now for Pico Turquino the highest peak in Cuba.

August 6

Left Manzanillo for Yara. At Yara had a man with horses waiting to take me to Nagua, which we reached in the afternoon. Made arrangements for a guide and two packers to take the stuff into the mountains as horses could not travel over the trail.

August 7

Got provisions for the packers.

August 8

Up the Yara River on foot with the three men and two dogs. Saw several Ruby Quail Doves along the river, and in the P. M. the dogs flushed a wild pig

Hutchinson

first indication of guano deposits on the island is given by Beatson (1816) who, as governor of the island, obtained the suggestion of Sir Joseph Banks to use it to the culture of "mangel-winch" which is the white or sugar beet" with success. He also appears to have used guano as fertilizer on other crop plants. According to Kitson (1931), Beatson reported considerable amounts of guano on Egg Island, an islet off the west coast of St. Helena. Kitson also states that in 1835 found a record of specimens of guano being sent from Egg Island to the mainland as early as July 16, 1808. From the import statistics (Great Britain, Parliamentary Sessional Papers, Trade and Commerce) it appears that St. Helena guano was brought to British ports intermittently from 1844 and 1860. The last two cargoes, in 1855 and 1860, respectively, were valued from £40.0 to £50.0 per ton, sug-

indicated.

Kitson states that Gallwey (sic) in the Report of the Governor of the Island to the Colonial Office, records in 1907 that a Mr. Cannon, phosphate expert of the firm of Jas. Morrison and Company, made 400 analyses of samples of supposed phosphate but regarded the results as unfavorable. Mr. Herdman, a manganese expert, considered, however, that good old guano existed on the eastern side of the island. Daly records that at Prosperous Bay a thin layer of brown phosphate, covering latitized basalt, probably represents the site of an old bird colony.

ILEU DAS CABRAS, SAO THOME

LATITUDE 0° 25' N., LONGITUDE 6° 43' E.

An islet off the northern coast of Sao Thome recorded by Lacroix (1906) as exhibiting the direct alteration of a trachyte into aluminum-phosphate. No analysis is given.

ISLANDS OF THE CARIBBEAN AND CAYMAN SEAS

Number of localities in the West Indies have yielded phosphatic guano. The geological history, and geochemistry of these deposits provide interesting problems.

CLIMATOLOGY

The whole region lies in the latitudes of the northeast trade winds. Air temperatures are generally high, averaging over 25° C. throughout the year. Rainfall at sea level is moderate to low. The greater part of the Lesser Antilles and the northern Lesser Antilles fall within the 1000-mm. isohyet. The southern members of the Lesser Antilles receive less rain, but the precipitation is very variable on local factors, elevated islands receiving more than flat ones. The Venezuelan and Dutch West Indian coastal islands are characterized by rainfall not exceeding 560 mm. and the localities being considerably less.

OCEANOGRAPHY

The oceanography of the Caribbean and the Cayman seas is complex (cf. Parr, 1937). In the surface temperatures are high, the

mean value being around 27° C.; corals flourish throughout the region. Most of the surface water is derived from the tropical Atlantic, but the exact point of entry is apparently variable. The tropical oceanic origin of this water is clearly responsible for the general low productivity of the region. Rakestraw and Smith (1937) found that in the central part of the Caribbean the phosphate content at the surface was very low, less than 0.1 milligram-atom per liter, but that higher values were observed in the Cayman Sea, along the Venezuelan coast, and in the region of the Lesser Antilles. The nitrate distribution was quite different. Minimal values were found along the Venezuelan coast, maximal in the northwestern part of the Cayman Sea. The minimum in the southern part of the region is probably due to increased biological consumption in this part of the area.

Off the Guianas and Venezuela, the South Atlantic Equatorial Current flows coastwise for some distance, through a region receiving considerable land drainage. The resultant access of nutrient salts of terrestrial origin



FIG. 72. Map of the Caribbean and Ceyman seas showing distribution of guano (mainly and in various places and islands) and phosphorus in the surface layer of the water.

in the higher biological production of the sea, rather than in accumulation of nitrate. Thompson (verbal communication) suspects that upwelling on the edge of the North Equatorial Current may be involved in enrichment occurring along the Guianan and Venezuelan coasts. It is interesting to note, according to Brown (1942), fishermen at the junction believe that the junction between blue and green littoral water is often productive, as is the case off Peru. The 200-meter contour off the Venezuelan coast is probably a complex current around the Venezuelan Leeward Islands leading to vertical mixing as well as transport from the east (Fiedler, and Lucas, 1943b). The relative productivity of the area is well indicated by general fisheries statistics published by Lobell, and Lucas (1943b). Although the Venezuelan coast occupies perhaps one-sixth of the coast line that they examined, its fisheries account for an estimated 100,000,000 out of the 161,000,000 pounds landed annually throughout the Caribbean. The best Venezuelan fishing grounds are found in the Venezuelan Leeward Islands, which are considered as phosphatic grounds below.

There are also productive fishing grounds on the Central American coasts of the Caribbean under consideration. These grounds exist largely to land drainage. The phosphatized localities recorded in part of the area are Vivorilla Cays, Honduras-Jamaica ridge between the Caribbean and Cayman seas is marked by banks, which are frequented by fish. According to E. F. Thompson (communication), the Serrana Bank is particularly productive. The hydrographic conditions on the banks bounding and within the Caribbean Sea are evidently very variable. Much more vertical movement may be expected than in the central Caribbean. Parr indicates a large eddy south of Jamaica, and there may well be local eddies on the productive banks. Similarly north a complex eddy south of Cuba with influx of water from the Gulf of

tip of Cuba probably introduce hydrographic complexities that may result in local upwelling. The productive western grounds are largely fished by Cayman islanders, whose knowledge surpasses that of other fishermen of the region (Fiedler, Lobell, and Lucas, 1943a).

Between Hispaniola and Puerto Rico the Mona Channel provides somewhat better fishing than might be expected in this generally unproductive part of the Antillean arc, and this is probably associated with local vertical mixing (E. F. Thompson, verbal communication).

ORNITHOLOGY

As far as it is possible to ascertain from the literature, the most important guano birds of the West Indies are the boobies, *Sula s. dactylatra* Lesson and *S. l. leucogaster* Boddaert. Several thousand pairs of *S. leucogaster* congregate to breed on Middle Cay of the Pedro group, along with 50 to 100 pairs of *S. dactylatra*, according to C. Bernard Lewis (in litt.). He writes: "I understand that the guano deposit on this Cay is better than on the other Cays, and I am told that *Sula dactylatra* produces a superior guano, while that of *Sula leucogaster* is considered valueless." Elucidating the latter statement he indicates in a later letter that *S. leucogaster* spends less time at the nesting site than does *S. dactylatra*, and that the nesting period of the former is limited to April and May, while the latter species is nesting for a period of six to eight months. Ludwig (in Sievers, 1898), one of the few observers who have published information on contemporary guano formation in the West Indies, states that on one of the islets of Ave de Barlovento boobies are responsible for the deposit. Cory (1909) notes only *S. leucogaster* from Ave de Barlovento, where it was common, breeding at the end of January. It is not improbable from Barnés' (1946) observations, that the same species has contributed much guano to the cave deposits on Mona Island.

At present the three boobies are clearly restricted in the number of their breeding grounds. In the Venezuelan Leeward Islands Cory records *S. l. leucogaster* on Ave de Barlovento, Los Hermanos, and Tortuga.

unlikely that these birds had different nesting sites, varying with the emergence of the land and other ecological factors. Old phosphate deposits not improbably represent old colonies of the two ground-breeding species of *Sula*. *Sula s. sula* (Linnaeus), which breeds exclusively in bushes and small trees, is limited in its distribution by this requirement, occupying sites where accumulation is not very likely to take place.

Terns, notably *Sterna f. fuscata*, *S. anaethetus melanoptera* Swainson, and *Anous s. stolidus* (Linnaeus) form considerable colonies and might be expected to have produced significant accumulation of guano. C. Bernard Lewis (in litt.), however, indicates that on Morant Cays, where the first and third of these birds breed, the guano deposits are poor, and the birds are mainly exploited for their eggs. *Fregata magnificens rothschildi* Mathews may be locally of some significance. Its numbers presumably are to some extent limited by the number of other sea birds that it can rob, though it has a much wider distribution in the Venezuelan Leeward Islands than have the boobies. *Pelecanus occidentalis*, known from all the Venezuelan and Dutch Leeward Islands save the *Islas de Aves* and *Los Hermanos* (Cory, 1909), is a possible contributor in the southern part of the Caribbean region.¹

Apart from the data supplied by C. Bernard Lewis, the only population study that gives any idea of the relative number of sea birds in the region is that conducted by Wetmore (1927) on Desecheo Island, which is not an important locality for guano. In 1912 he estimated the population, late in the breeding season, to have consisted of:

¹ *P. o. occidentalis* Linnaeus occurs throughout the greater part of the Caribbean region, perhaps intergrading with *P. o. carolinensis* Gmelin in Cuba. The latter bird follows the coast of the Gulf of Mexico around through Central America to the southern shores of the Caribbean. *P. o. occidentalis* is certainly found in Aruba and probably in Curaçao and Bonaire. It is uncertain which race inhabits the Venezuelan Leeward Islands (Wetmore, 1945).

Fregata magnificens rothschildi

In later years the brown booby population apparently declined.

DESCRIPTION OF THE ISLANDS

It is convenient to consider the localities in four groups:

Islands in the Cayman Sea and the western reefs of the Caribbean

The Greater Antilles and associated islands

The Lesser Antilles

The Venezuelan and Dutch Leeward Islands

ISLANDS IN THE CAYMAN SEA AND THE WESTERN REEFS OF THE CARIBBEAN

It is convenient to start a survey in the southwestern part of the region, beginning with two little-known groups of deposits and then passing to the Swan and Cayman Islands, to the west of the true Caribbean, and to the islets on the reefs that separate the latter from what Parr (1937) has termed the Cayman Sea. In general, all of these islands and reefs represent limestone-crowned submarine peaks. At least the Cayman Islands indicate two periods of emergence, separated by limited coastal submergence in the Pleistocene or Recent, comparable with that known along the shores of the Greater Antilles. Climatological data are meager, but the rainfall on Grand Cayman Island is reported as about 1956 mm. per annum (United States Hydrographic Office, 1927c), a rather high value for sea level in the West Indies, and on Swan Island as about 1700 mm. per annum. The mean annual temperature at the latter station is 26.95° C., with observed extremes being 17.8° C. and 33.5° C. (Reed, 1926).

OLD PROVIDENCE ISLAND

LATITUDE 13° 19' N., LONGITUDE 81° 25' W.

A high island rising to an altitude of 302 meters and with a maximum length of rather over 7 kilometers. The island is said to be extremely fertile (United States Hydrographic Office, 1927c). The only evidence that guano

may hereafter be discovered in lands which compose the canton ~~is~~. This decree is printed in it with a covering letter by Charles, British Consul at Cartagena, the Earl of Clarendon in Great Parliamentary Sessional Papers, the occurrence must be regarded as a blameworthy.

VIVORILLA CAYS

52° N., LONGITUDE 83° 20' W.
The cays called Vivario Cays, a small low coral cays on the Miskito support numerous trees and to the northwest there is a similar to the Caxones or Hobbies. According to Capt. Henry Coryton, in a letter from Rear Admiral Lowe to the Secretary of the Admiralty dated May 10, 1856 (Great Parliamentary Sessional Papers, 1857) the bark "Rhoderic Dhu" (Capt. 300 tons) was loading guano at the cays. The work was difficult and it took two weeks to get the guano dug out but two-thirds of the material was present. The bark had obtained guano previously at Vivorilla Cays, and a Captain New York was said to have obtained guano from the cays, as had people from the Ullmann lists Vivorilla guano but without an analysis or

THE SWAN ISLANDS

25° N., LONGITUDE 83° 56' W.
Great Cayman and Honduras small islands, the larger rather 1000 feet long and of maximum width 18.3 meters above sea level. east in part, raised coral islands (1935), though an exposure of material like Fuller's earth appears on Great Swan under the coral cap

Swan by phosphate diggers. Some portions of the surface phosphate were reduced in value by intermixture of organic soil derived from the leaves of trees (Pacific Guano Company, 1876). Three types of phosphatic guano are said to have been present, an upper soft earthy layer, dark brownish in color, containing phosphate equivalent to about 60% $\text{Ca}_3\text{P}_2\text{O}_8$; a semipetrified guano, of light brown color, comparatively free from water and containing the equivalent of 55% to 60% $\text{Ca}_3\text{P}_2\text{O}_8$; and a compact phosphate rock, brown or opaque white, yielding the equivalent of 75% to 80% $\text{Ca}_3\text{P}_2\text{O}_8$. These chemical data, given by the Pacific Guano Company, doubtless were optimistic. The total quantity present was estimated in 1858 by a United States Government commission as 3,000,000 tons. Analyses were also published by Nesbit and by Dietrich, neither of whom seems to have had the best material submitted to him.

Nesbit gave:

H_2O	9.28%
Organic matter	11.74
CaO	19.15
$(\text{Al}, \text{Fe})_2\text{O}_3$	16.12
$(\text{Al}, \text{Fe})\text{PO}_4$	2.23
P_2O_5	14.52 (= 31.70% $\text{Ca}_3\text{P}_2\text{O}_8$)
CO_2	1.23 (= 2.79% CaCO_3)
SO_2	0.64 (= 1.33% $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)
Alk. salts	2.92
SiO_2	22.15

Dietrich found:

H_2O	13.50%
Organic matter and NH_3	13.66, of which 0.57% N
Earthy phosphates	40.0
Sand, gypsum, etc.	32.84

For a predominantly coral island the amount of iron and aluminum found by Nesbit is high.

Lowe says there is also a deposit of phosphate at the eastern end of Little Swan Island. This smaller island, the surface of which is much fissured, has breeding colonies of *Sula l. leucogaster* (sub *S. sula*) nesting on rough ground covered with *Sesuvium*, and of

Declassified and Approved For Release 2013/07/29 : CIA-RDP86-00178R000100060011-2

	POWDER	LUMPS
H ₂ O	20.12%	6.30%
Organic matter and combined water	10.96	7.29
Fe ₂ O ₃	5.88	2.97
Mn ₂ O ₃	tr.	—
Al ₂ O ₃	tr.	tr.
CaO	31.15	44.52
MgO	0.44	—
K ₂ O	0.16	tr.
Na ₂ O	tr.	0.11
SO ₃	0.10	—
P ₂ O ₅	24.36	35.43
P ₂ O ₅ water soluble	0.45	0.03
CO ₂	2.00	3.06
SiO ₂	2.42	0.07
Cl	tr.	tr.
Sand	2.41	0.25
N	0.45	0.03

An account of the occurrence of guano on the Cayos de los Jardinillos, west of the Isle of Pines, about latitude 20° 40' N., longitude 81° 30' W., was apparently published by Reinoso (1859), but his work has not been available.

Palmer (1900) indicates that "Alacran Rocks in the Caribbean Sea" were abandoned as a guano source, because the value of the deposits was negligible. This may refer to Alacranes Cay, off Point Alacranes (latitude 22° 53' N., longitude 83° 27' W.).

MORANT KEYS

LATITUDE 17° 26' N., LONGITUDE 77° 55' W.

South southeast of the extreme eastern end of Jamaica, breeding grounds for large numbers of sea birds. Eggs are collected commercially, but, according to the "West Indies pilot" (United States Hydrographic Office, 1927a, p. 360), the supply of guano is of poor quality. This is confirmed by C. Bernard Lewis (*in litt.*) who hopes to publish a full account of the Morant and Pedro Cays. He indicates that the bird colony has been affected by removal of vegetation and its modification by burning. He believes that the guano collected here was not produced by the contemporary bird colony. No analysis appears to have been published.

NAVASSA

LATITUDE 18° 25' N., LONGITUDE 75° 01' W.

A small elevated coral island set on a

submerged bank 22 to 36 meters deep. The island is pear shaped, about 3.7 kilometers long. There is a well-marked terrace which apparently slopes northwest, the cliff being 2 to 3 meters high on either side of the northwest point of the island, and up to 20 meters at the southeast end (fig. 74). D'Inyilliers (1891), who gives the best description of the island, is not entirely explicit on the matter. Within the terrace the island rises steeply to the rim of a flat central area lying at about 70 meters above sea level, the maximum elevation of the rim being 78 meters. This area presumably represents the lagoon of an elevated atoll. The whole island is stated by D'Inyilliers to be composed of recent coral limestone. No determinations of the fossils appear to have been made, so that the age is not adequately established. The upper part of the limestone is colored in places a deep blue, but shafts dug in the upper plateau show the main material to be a pure white, often amorphous calcium carbonate. A shaft from the plateau to just below sea level disclosed nothing but pure limestone. No analyses have been published, and there is no indication if dolomitization has taken place. The surface of the island is very irregular, being marked with cylindrical holes and narrow fissures trending north 20° west, south 20° east. Some of the holes are conical and smooth as if due to eddying water. Gaussoin (1866) noted blow holes at the top of the inner cliff. The climate appears to be dry, with no protracted rainy season. Soil is poorly developed, and no fresh water is available. The island is, however, covered with scrub palms, rank grass, cactus, large century plants, and a few species of small trees.

The phosphate deposits are purely superficial, filling the pits and fissures in the surface of the limestone. Schmidt (1921) supposes that these fissures are collapsed caves; but it is more probable that they were formed by subaerial dissection immediately after the emergence of the island and are comparable to the pinnacles and pits formed on Aldabra Island and still more strikingly on the elevated Pacific phosphate islands. In a few cases phosphate pockets extended down 10 meters and were 4 to 5 meters wide, but usually the fissures are only just wide enough

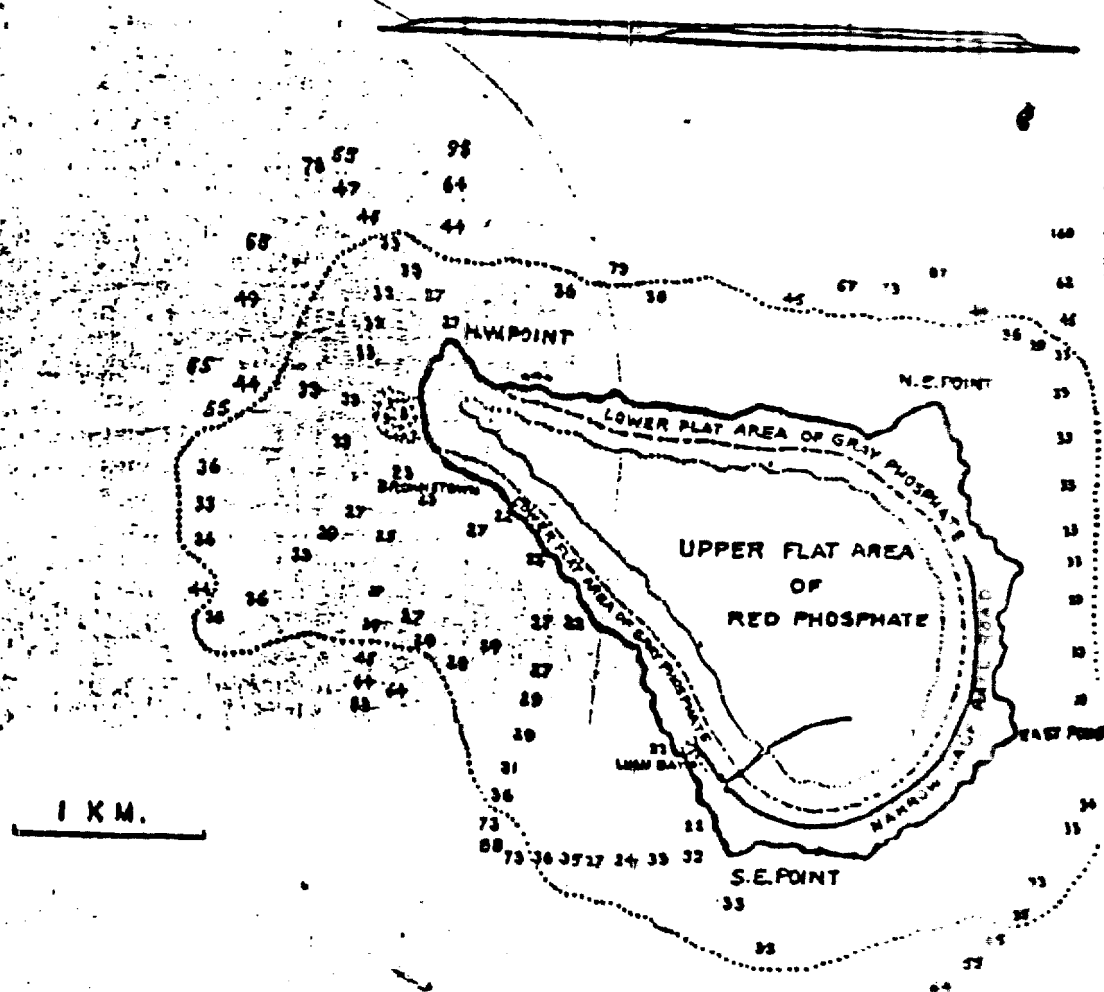


FIG. 74. Map and elevation of Navassa Island. After Schmidt and the United States Hydrographic Office.

to permit a workman to remove the material. The deposits occur throughout the lower terrace, and more irregularly on the upper plateau. D'Inwilliers estimated that the lower terrace originally contained 366,000 to 488,000 tons, and the upper plateau contained 300,000 to 360,000 tons.

Chemically the material of the terrace and plateau differ, the former yielding so-called gray phosphate, the latter red phosphate. Typical analyses of the two kinds (see column 2, this page) are given by D'Inwilliers, unfortunately not in entirely comparable form.

Other analyses have been published by Nesbit (1860), Ulbricht (1866), and Voelcker (1875). One of Nesbit's analyses gave:

	GRAY	RED
H ₂ O	2.33%	14.22%
H ₂ O combined and organic matter	7.63	(ignition loss)
CaO	34.22	23.090
MgO	0.51	tr.
Al ₂ O ₃	15.77	18.425
Fe ₂ O ₃		9.796
(Na,K) ₂ O	0.86	—
P ₂ O ₅	31.34	29.779
SO ₃	0.28	1.160
Cl	0.15	—
CO ₂	1.84	3.527
		(by difference)
SiO ₂	4.53	—

(Al,Fe)PO₄ 27.71% and (Al,Fe)₂(PO₄)₃ 9.59%, and presumably refers to red phosphate. The

Other published analyses refer in all probability to the gray material, which was commercially preferred. As far as can be ascertained, the total $(Al,Fe)_2O_3$ content was always in excess of 10%. Voelcker gives two analyses, presumably referable to gray phosphate, in which he separated Al_2O_3 and Fe_2O_3 , obtaining 9.11% and 9.48% of the former and 4.18% and 4.49% of the latter oxide. It would therefore appear that alumina is roughly twice as abundant by weight as is iron oxide, in both red and gray phosphates. The SiO_2 content varies from 2.55% to 4.28% in the various analyses. Nesbit records 4.21% and 0.28% N. Gaussoin (1866) states that most of the deposit consisted of spherical grains, the size of mustard seed to that of rockshot. Hard crusts lined cavities in the limestone, but he noted no crystalline material. Many bones are recorded.¹

In spite of the highly improbable statement in the "West Indies pilot" that the island contains veins of iron pyrites, D'Inville is emphatic that he encountered nothing but coral rock and phosphate on Navassa. The origin of the considerable quantity of iron and alumina in the phosphate is therefore puzzling. D'Inville supposed it to come from sea water, and therefore to be more abundant where undisturbed evaporation could occur, in the old lagoon, than on the exposed terrace. There is, however, every reason, from the known composition of sea water, to reject this view. Du Toit suggests that a residual soil was formed by the decomposition of large amounts of limestone, and that the iron and aluminum are derived from this soil.

ALTA VELA ISLAND

LATITUDE $17^{\circ} 28' N.$, LONGITUDE $71^{\circ} 38' W.$

An islet about 1.2 kilometers long and 0.8 kilometers wide, rising to a summit 152.4 meters above high water. Cooke (1921) shows the island of Beata as covered with alluvial deposits, but Alta Vela is obviously composed of more resistant rock. Los Frailes, a cluster of white-topped rugged rocks be-

¹ Since the above was written, the existence of very fine crystalline material referred to brushite in the Vaux collection of the Academy of Natural Sciences of Philadelphia has come to my attention. The crystals occur on whitish rock, presumably from the terrace.

tween Cabo Falso and Alta Vela, are presumably covered with guano. Baron de Wimpffen (1797) observed a "prodigious number of sea birds" on Alta Vela. "a mere rock, with a few green spots about it." Phosphate was worked here in the nineteenth century, but no good account of the occurrence seems to be available. Voelcker (1875) gave four analyses, one of which indicated 11.29% CaO and 4.01% CO_2 ; the other samples were free from calcium and carbonate. Alumina appears to be the principal base in all specimens, and a rather large amount of insoluble siliceous material was present. The Alta Vela phosphate is clearly the result of the phosphatization of an igneous rock, and the chemical data are discussed at greater length below.

The British statistics on imports (Great Britain, - Parliamentary Sessional Papers, Trade and Navigation, 1865-1890) indicate that between 1865 and 1876 19,813 tons of guano were received from Haiti and Santo Domingo. This material was obviously mainly phosphatic guano, usually realizing £4.0.0 to £6.0.0 per ton, though the 1871 cargo was poorer and the last cargo of 560 tons received in 1876 was much richer, fetching £8.0.0, which was a very high price for a phosphate at that time. From 1871 to 1880 an aggregate of 54,537 tons of unenumerated manure, realizing from £2.12.0 to £3.18.0, were imported, and from 1882 to 1890, 17,992 tons of phosphate of lime and rock were received at British ports and fetched from £2.3.0 to £4.10.0. It is quite possible that the whole of the unenumerated manures and phosphate of lime and rock actually represents Alta Vela phosphate.

DESECHERO

LATITUDE $18^{\circ} 23' N.$, LONGITUDE $67^{\circ} 29' W.$

Shown by Hubbard (1923) as an island about 2 kilometers long and 1 kilometer wide, rising to a height of at least 150 meters in the center. This central hill is heavily wooded (United States Hydrographic Office, 1927a, p. 545). The island appears to be composed largely of Cretaceous shales. There is a Pleistocene or Holocene raised beach deposit (San Juan formation) above the shore line, composed of gravels, formed from rock fragments and shells, cemented together by

RED
4.223%
ignition
(loss)
3.090
tr.
8.425
9.796
—
9.779
1.160
—
3.527
Difference
—
9.59%
-ate. The

"guano," presumably phosphatic (Hubbard). The small quantity and mode of occurrence prevent the deposit from being of commercial significance. As has already been indicated, *Sula l. leucogaster*, the brown booby, is common. *S. s. sula* also nests on the island, though presumably in the wooded part above the beach. *Sterna anaetheta melanoptera*, the bridled tern, and *Anous s. stolidus*, the brown noddy, also have breeding colonies on the island (Wetmore, 1918).

MONA

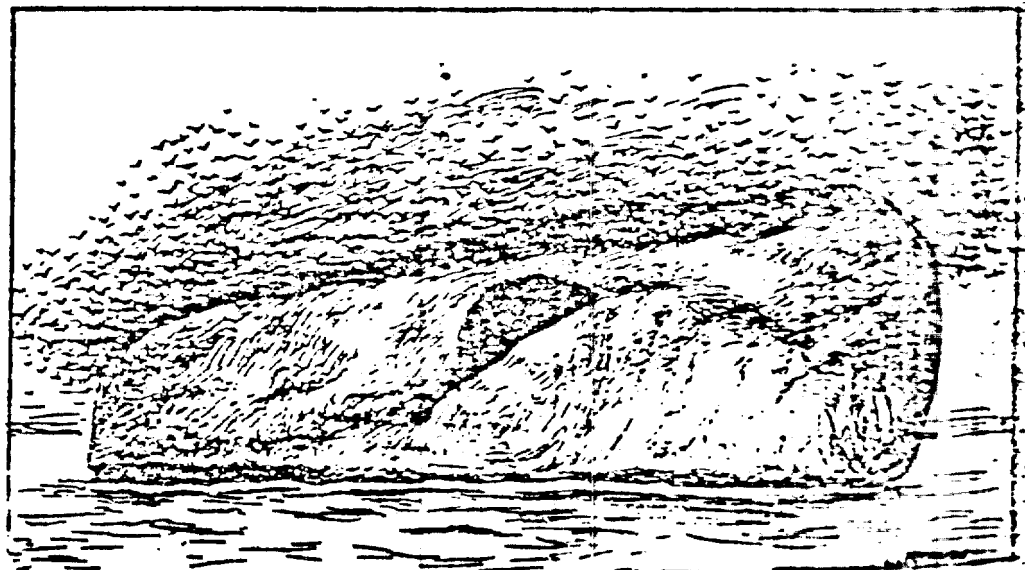
LATITUDE 18° 05' N., LONGITUDE 67° 51' W.

Described by Schmidt (1926) as a block of Tertiary limestone 6.5 miles long and 4 miles wide, with precipitous cliffs, up to 85 meters high, save on the southwest side, where there is a wide terrace 3 to 4 meters above sea level. A smaller islet, Monito, about 400 meters in diameter, lies 3 miles north-northwest of Mona. Primitively the interior plateau of the island was largely forested, but the general appearance suggests great aridity, owing to the porous nature of the limestone. Meteorological data are not available, but according to the "West Indies pilot" (United States Hydrographic Office, 1927a) the rainfall is strictly seasonal, the chief wet season being February to mid-May,

with subsidiary rains from August to October; the intervening months are almost rainless.

The limestone is honeycombed with caves, particularly in the upper parts of the cliff. Hübener (1898) indicates that the entrances of these caves lie along old strand lines corresponding to various stages in emergence. The caves are warm and damp. Pools of water may be found in them for a large part of the year, and stalactites and stalagmites are well developed. Where light enters, algae grow on the damp surfaces, so that the whole interior is bathed in a beautiful green light. In one smoke-blackened cavern pirates amused themselves by drawing pictures of ships and of their fellows down from gibbets.

The phosphate deposits are found on the floors of the caves. Schmidt states that the phosphate is derived from bat droppings. Hughes (1885) describes a similar occurrence in Barbuda. Hübener, however, specifies that bat guano is limited to a few localities on Mona. His supposition that the phosphate is derived from animal and plant material from which the organic fractions were leached by sea water when the caves were above sea level is obviously unlikely. Since the inaccessible cliffs of Mona and the smaller Monito are, according to Schmidt, even now



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colonized by sea birds, it is reasonable to suppose that, whatever the contribution of the bats, that of the birds is also very extensive. Such a conclusion is obviously supported by the sketch of Momito, given by Hübener, and here reproduced (fig. 75). It is, moreover, obvious that unless an abnormally large population of marine chironomids was available, or an abnormally great number of fish-eating bats were present, the phosphate of the guano cannot have come from the sea. This conclusion in itself makes the avian origin of the Mona phosphate almost certain. Schmidt, and Barnés (1946) give lists of the birds of the islands. *Sula l. leucogaster* was without doubt the most important producer of guano. Barnés noted 87 nests of the species in a large cave called El Toro. *Sula s. sula* is common, and *Fregetta magnificens rothschildi* breeds on bushes at the top of the plateau. Colonies of *Anous s. stolidus* occupy inaccessible parts of the cliff, but the noddy formerly bred on the plateau. *Sterna unanetha melanopus* and *S. fuscata* also frequent the island. Barnés noted boobies, terns, and the gull *Larus atricilla* Linnaeus flying over large schools of tuna in the channel between Mona and Momito.

From the accounts of both Shepard (1882) and Hübener it is clear that the most striking feature of the phosphates of Mona and of Momito was the quantity of crystalline material present, though brown amorphous phosphate containing organic matter also occurred. Shepard described two new minerals, one being the well-established species monetite, CaHPO_4 , the other, monite, provisionally examined to be carbonate-hydroxylapatite (Strunz, 1939; Frondel, 1953). The crystalline material of the caves of both islands seems to have been largely monetite associated with gypsum. Such deposits presumably were deposited from a solution in which the ratio of $\text{CaO}:\text{P}_2\text{O}_5$ was probably less than in the guano. The hydroxylapatite in part represent the remaining guano. A mushroom-shaped laminated stalagmite from a cave on these islands was analyzed for Shepard (1882) with the following results:

	ANALYSIS BY ROBERTSON	ANALYSIS BY C. W. SHEPARD, JR.
Water, organic, etc.	9.76%	10.91%
CaO	40.27	39.98
(Al,Fe)PO ₄	—	2.90
P ₂ O ₅	40.81 (total)	38.80
SO ₃	6.85	6.80
Insol.	0.53	1.13

As Shepard indicates, the molecular ratio $\text{CaO}:\text{P}_2\text{O}_5$, after correction for gypsum, is 1:0.436. The material is presumably a mixture of monetite and an apatite. A sample of Mona guano, analyzed by Goessman (1892), indicates a more normal phosphatic deposit:

H ₂ O	13.32%
N	0.76
P ₂ O ₅	21.88
CaO	37.49
Insol.	2.45

CAJA DE MUERTOS, PUERTO RICO

The "West Indies pilot" (United States Hydrographic Office, 1927a) describes a Muertos Island as 7.2 kilometers from the coast, 2.4 kilometers long, and of maximum elevation 74.1 meters, situated about 12 kilometers southeast of Ponce. Gile and Carrero (1913) record guano forming a deposit apparently nearly 2 meters (6 feet) thick, northeast of the lighthouse on the bay. They indicate a nitrogen content of from 0.21% to 1.32% N, and a phosphate content of from 14.58% to 33.44% P_2O_5 . Of four samples analyzed, three contained over 31% P_2O_5 . Stutzer (1911) states that the deposit contained 140,000 tons and says, on the authority of Juneau, that the guano consisted of a loose, light brown, earthy material, containing darker, somewhat more phosphatic lumps.

VIRGIN ISLANDS

Heiden states that phosphatic guano was obtained from the Virgin Islands in the nineteenth century. Though nothing is known of the occurrence, Guano Island, about 1.6 kilometers west of Great Camanoe, would seem to be a reasonable source.

THE LESSER ANTILLES

The Lesser Antilles, or Caribbees, are

	I	II
H ₂ O	7.10%	2.39%
Organic		
NH ₄ salts	2.72	7.93 (org. + comb. H ₂ O)
CaO	40.61	39.48
MgO	2.83	1.17
Na ₂ O	—	—
K ₂ O	tr.	—
Fe ₂ O ₃	0.49	—
P ₂ O ₅	43.28	41.34
SO ₃	3.23	4.57
Cl	0.06	—
SiO ₂	0.49	2.28
N	0.03	0.139

Allowing the MgO as Mg₃P₂O₈ and the SO₃ as CaSO₄, these analyses give values for the molecular ratios CaO:P₂O₅ of 1:0.411 and 1:0.408, respectively, presumably corresponding to a mixture of apatite and monetite. In the first specimen, in which the water content is high, some brushite may have been present. Piggot (1857) gives another analysis in which 35.95% CaO is taken to combine with 46.22% P₂O₅ and 5.73% H₂O; this material, like the materials studied by Nesbit, was probably mainly monetite. Morfit states that 0.16% soluble P₂O₅ was present, but this finding is probably of no significance in view of the difficulty in determining the solubility of such minerals. A specimen analyzed by Anderson (1855) contained 75.69% alkaline earth phosphate with 0.78% soluble P₂O₅; the nature of this specimen is obscure. It is evident, from Shepard's original account, that some fluorine was present in the so-called pyroclastic.

Considering all the available data it seems probable that the Los Monges phosphate consisted largely of monetite mixed with apatite. Where the phosphate rested on reef limestone, which in places may have been dolomitized, it seems probable that an underlying layer of apatite also developed. Martinite or carbonate-whitlockite was certainly present, and brushite may have also occurred. The lower phosphate content of the outer layer may have been due either to apatite or to whitlockite. The former seems more probable, as the whitlockite from the locality is described as earthy, whereas the crust was evidently a hard coherent material. It is most

unfortunate that so little is known of this extraordinary deposit, which probably has its closest analogue in some of the deposits of the islands of the Gulf of California, such as San Pedro Martir and the Farallon de San Ignacio (pp. 131-132).

CHRONOLOGICAL ASPECTS OF THE GUANO DEPOSITS OF THE CARIBBEAN AND CAYMAN SEAS

In view of the lack of information about many of the localities, it is difficult to present the data that are available in definite categories. It has seemed, therefore, first to list the localities that have been discussed above, with such information that may bear on the chronology of their deposits. The term "contemporary phosphatization" is used to imply that phosphatization is occurring when exploitation began.

Old Providence. No information
 Vivorilla Cays and Caxones. Apparently at contemporary phosphatization
 Swan Islands. Phosphatization at least not contemporary
 Cayman Islands. Phosphate certainly ancient
 Karrenfeld on Pleistocene or older limestone
 Serrana Cays, etc. Some phosphatization apparently still occurring
 Pedro Cays. Some phosphatization apparently still occurring
 Bahama Islands and Cuba. No information
 Morant Cays. Not contemporary
 Navassa. Certainly ancient in pockets of Karrenfeld at two levels
 Alta Vela. Contemporary bird colony, but aluminum phosphate perhaps ancient
 Deschêo, San Juan formation, Pleistocene or post-Pleistocene, but not contemporary
 Mona and Monto. Large bird colony on Mona, but the general impression given by the counts is that most material is ancient
 Puerto Rico. No information
 Virgin Islands. No information
 Redonda. Superficial phosphatic guano apparently contemporary. Aluminum phosphate may be Pleistocene or even older
 Perle. Probably not contemporary
 Diamant. Probably contemporary
 Sombrero. Certainly ancient, presumably Pleistocene or older
 Little Scrub Island. Probably not contemporary
 St. Martins Island. No adequate information
 Bird Island. Apparently contemporary

Frayer. Apparently contemporary
 La Sola. Apparently contemporary
 La Bernandosa. Apparently contemporary
 La Bernandosa. Contemporary phosphatization
 La Bernandosa. Not contemporary
 La Bernandosa. Contemporary
 La Bernandosa. Contemporary
 La Bernandosa. A little contemporary guano;
 aluminum phosphate ancient, but time of
 formation unknown

La Bernandosa. Probably Pleistocene
 La Bernandosa. No information
 La Bernandosa. Apparently Pleistocene
 La Bernandosa. Apparently Pleistocene
 La Bernandosa. Apparently not contemporary

The localities that appear to have had
 traces of birds actually producing guano in
 the last 150 years are the Serrana Cays, the
 Loro Cays, Monito, Bird Island, and five
 of the Venezuelan Leeward Islands.
 The modern guano probably coated the old
 aluminum phosphate on Alta Vela and
 Redonda. In all at most half of the islands or
 groups of islands for which any information
 exists seem to have had large enough bird
 colonies for contemporary deposition to have
 occurred, but in many cases the amount of
 phosphate produced was very small. Except

doubtful if any of the commercially significant
 deposits were of recent date. Even where there
 was a veneer of guano over a massive quantity
 of aluminum phosphate, the latter may be of
 considerable antiquity and the modern guano
 a quite late addition produced by birds that
 had nothing to do with those producing the
 main phosphatization.

The deposits of the Cayman and Swan
 Islands, Desecheo, Sombrero, Navassa, Bon-
 aire, Curaçao, and Aruba, which collectively
 must have greatly exceeded those produced
 on the islands with bird colonies still in exist-
 ence in the nineteenth century, all may be
 Pleistocene, though at least in the case of
 Desecheo a Holocene date is possible. The
 aluminum phosphate on Alta Vela, Redonda,
 and Gran Roque may well belong with the
 massive deposits on some of the limestone
 islands. While, without detailed correlation
 of the Pleistocene and post-Pleistocene
 deposits on all these islands, it is impossible
 to arrive at any definite conclusion, the
 general impression left by the available data
 is that more intense phosphatization occurred
 throughout the region at some past and
 probably Pleistocene time than was taking
 place at the time of the arrival of European
 man.

PHOSPHATIZED LOCALITIES ALONG THE NORTHEAST COAST OF SOUTH AMERICA AND IN THE ADJACENT OCEAN

St. Paul's Rocks and Rata Island of the
 Fernando de Noronha group are apparently
 all the sites of active guano production.
 Two localities or groups of localities, at
 which considerable phosphatization of pri-
 mary rocks has occurred in the past, lie on
 the northeastern coast of South America.
 Since this region is very much wetter than
 either the Caribbean or the Brazilian islands
 farther south, it is therefore conveniently
 considered in a separate section.

OCEANOGRAPHY

St. Paul's Rocks and the Fernando de
 Noronha group lie in a part of the Atlantic
 which may be enriched by upwelling in the
 Equatorial Counter Current and which

seems to have a richer avifauna than most of
 the tropical part of this ocean. The Southern
 Equatorial Current flows along the whole
 of the coast of northeastern South America,
 but the littoral waters are strongly modified
 by the discharge of the Orinoco and the
 Amazon. Though Hentschel (1935) records
 many birds off the mouth of the Amazon,
 Murphy indicates that the great turbidity
 of much of the inshore part of the Atlantic in
 this region has a very adverse effect on the
 avifauna, most of the ordinary oceanic
 species being absent from British Guiana.
 Farther east, off French Guiana, there appears
 to be clearer water, the influence of the
 Orinoco not reaching so far east or the
 Amazon so far west (Heilprin, 1906). It is

	Tons P
Old deposits of Peru and Chile, due to bird colonies existing until the nineteenth century	838,760
Ancient deposits of Chile (excluding Mejillones)	537,768
Mejillones	595,000
	1,971,528

Of this quantity 500,400, or approximately one-fourth, was present on the Chincha Islands.

The African deposits are less adequately known. On the Northern Islands at least 218,000 tons of guano were present, corresponding to 8720 tons of phosphorus. From the Colonial Islands about 75,000 tons of old guano containing about 12% P appear to have been imported; this corresponds to about 9000 tons P. The whole coast therefore probably produced a quantity of guano equivalent to about 18,000 tons of phosphorus.

The original reserves on the islands of the Pacific coast of California are unknown. Within the Gulf, Raza Island is supposed to have borne 70,000 tons of phosphatic guano apparently containing about 17.2% P, and so corresponding to 12,000 tons of phosphorus. Krull regarded this island, San Pedro Martir, and the Farallon de San Ignacio as the three most important sources of phosphatic guano within the Gulf of California. If all three islands were equally important they would together have had a reserve of 36,000 tons of phosphorus. This estimate is probably excessive; it may suggest that the whole production of both the Pacific and Gulf coasts was of the order of 50,000 tons of phosphorus, but this figure is so much greater than the African estimate that it must be accepted with great caution.

In making a rough estimate for the entire world it seems best to allow 2,100,000 tons of phosphorus for all the western continental coasts and not to attempt further refinements which the inadequate African and Californian data do not properly permit.

The total quantity of phosphorus present in the supposedly post-Pleistocene phosphatic guano of the central Pacific islands has already been estimated as 211,000 tons, while

that of the western Pacific islands has been given as 53,000 tons. Since these figures include no data from Clipperton Island, Johnston Island, the Hawaiian Leeward Islands, or Flint Island as well as from the unimportant localities, an over-all estimate of 300,000 tons for the phosphatic guano islands of the Pacific is reasonable.

The Huon and Chesterfield Islands are supposed to have borne rather over half a million cubic meters of guano containing about 30% P_2O_5 ; this may probably be taken as equivalent to 69,000 tons of phosphorus. The original estimate is likely to be excessive but is counterbalanced by the unestimated guano from the islands of the Barrier Reef region. The southern coast of Australia appears to have produced the equivalent of 2000 tons of phosphorus, and the western coasts about 24,000 tons, though there is a two-fold uncertainty in this figure. For the whole coast of Australia and the islands of the adjacent seas, a figure of 100,000 tons P seems reasonable.

The data already given for the China Sea also indicate an original reserve of about 100,000 tons P.

The islands of the western Indian Ocean bore about 300,000 tons of P_2O_5 . Assuming that about half this is of post-Pleistocene origin, which may be an underestimate, the total phosphorus deposited since the Pleistocene would be 69,000 tons. No satisfactory estimates can be made for Latham Island or the other islands off Africa or in the Red Sea. The Kuria Muria Islands yielded 37,707 tons of guano to British vessels, and this may have contained 4000 tons of phosphorus. It is probable that all the localities in the Indian Ocean and those of the few guano islands of the middle Atlantic yielded together not more than 100,000 tons P.

For the Caribbean and Cayman seas no satisfactory estimate can be made. The most important insular phosphates of the region, on Curaçao, Sombrero, Navassa, the Swan and Cayman Islands, Redonda, and Alta Vela seem not to be post-Pleistocene. Bird Island is the only island with a modern bird colony for which there is both an estimate of the mass and an analysis. Both the estimate of 200,000 tons and the phosphorus content of 47.5% P_2O_5 are probably

bore about 44,000 tons of phosphorus. It is, however, very unlikely that the estimate is reliable or that the analysis refers to typical material. Orchilla seems to have borne 20,000 to 40,000 tons, containing 22% P_2O_5 , or about 3500 tons, of phosphorus, probably deposited since the Pleistocene but not by a contemporary colony. From none of the other islands are the data so good. For the purposes of the present discussion, it is assumed that the Caribbean, eastern South American, and Patagonian coasts bore about 100,000 tons of phosphorus deposited since the Pleistocene.

Since the total quantity of phosphorus in stable deposits outside the tropics is very small, the quantity of phosphorus removed as guano in post-Pleistocene time may be given as:

	Tons
Western continental coasts	2,100,000
Pacific	300,000
Australia	100,000
China Sea	100,000
Western Indian Ocean, etc.	100,000
Eastern coasts of Americas	100,000
Total	2,800,000

Of this total, the Chincha Islands bore more than one-sixth, and the Mejillones deposits more than one-fifth. The contributions of all other individual deposits are small compared to those of these two localities. Of the South American deposits, which make up over two-thirds of the total, rather over half are ancient post-Pleistocene, and rather under half from localities with contemporary colonies. In the Pacific these relationships are probably reversed. In general it is safe to conclude that roughly half the guano deposits of the world were still growing during the early part of the nineteenth century and half were due to ancient but post-Pleistocene bird colonies.

THE TOTAL QUANTITY OF PHOSPHATIC GUANO IN SUPPOSED PLEISTOCENE DEPOSITS

Turning now to the well-elevated islands, the deposits of which appear to be Pleistocene or possibly, according to some investigators, late Tertiary, fairly good data are available for the important islands of the Pacific area

For the western Indian Ocean, an arbitrary assignment of half the reserve to post-Pleistocene and half to Pleistocene deposits has been made. The islands of the Caribbean and Cayman seas again introduce the most significant uncertainties, as no adequate estimates are available for any of the important localities except Navassa. On this island there appear to have been between 700,000 and 850,000 tons of phosphatic rock, containing 96,000 to 117,000 tons of phosphorus. The British statistics indicate that 285,594 tons of phosphatic guano, unenumerated manures, and rock phosphate were shipped from the British West Indies, Haiti, and Santo Domingo between 1852 and 1892. Some material must have gone to continental European ports. Much phosphate, particularly from Navassa and Sombrero, was certainly brought to the United States, though no adequate statistics are available. From Curaçao it is known that 624,000 tons were exported before 1924 and that the deposit is still being worked. From Little Curaçao 100,000 tons of phosphate were removed early in the history of exploitation of the region. It is probably safe to conclude that the total quantity of phosphate removed from the islands now exhausted was of the order of 1,000,000 tons and to assume an original reserve of 2,000,000 tons for Curaçao. Assuming 15% P, corresponding to 32.7% P_2O_5 , the phosphorus in the ancient deposits of the region would be 450,000 tons. It is obvious that such a figure is little better than a guess, but it is small compared to the original phosphorus reserves of some of the better-known localities, so that it will not introduce great errors into the estimate for the world.

	Tons
Makatea	5,000,000
Ocean Island	3,800,000
Nauru	15,400,000
Kita Daito Jima	860,000
Okino Daito Jima	860,000
Angaur	405,000
Other western Pacific islands	212,000
Christmas Island	5,400,000
West Indian Ocean	69,000
Caribbean and Cayman seas	450,000
Total (to three significant figures)	32,500,000

The occurrence of phosphatic deposits under a plant cover, and without a large contemporary bird colony, is strongly suggested by the available accounts of the islands of the China Sea, notably all of those of the Dangerous Ground except Spratly Island, and Woody Island, if not other members of the Paracel group. An adequate interpretation of this region is, however, impossible without more ornithological information.

The islands of the western parts of the Indian Ocean may perhaps provide cases that are comparable. Fryer thought that the phosphate deposits were far more extensive than would be expected from modern bird colonies. It is, however, difficult to distinguish between ancient phosphatic rock, probably of Pleistocene age, as is certainly found on Aldabra, and more recent though not contemporary phosphatic guano which probably was present on many of the islands. The account of the phosphate of San Juan de Nova strongly suggests that it was formed by a relatively recent but not contemporary bird colony.

In the Caribbean and Cayman seas there appear to be similar indefinite indications of old post-Pleistocene deposits not formed by contemporary colonies. The deposit on El Dorado Islet, Orchilla, and the little-known occurrence of guano on Vivorillo Cays and the Caxones seem to provide examples. It is difficult, in this region as in the western Indian Ocean, to distinguish Pleistocene from Recent phosphatization. The guano incorporated into the San Juan formation of Desecheo and similar deposits in other parts of the West Indies may ultimately turn out to be comparable to the post-Pleistocene guano on vegetated atolls in the Pacific.

These few instances, unsatisfactory though they be, do at least suggest that the occurrence of buried post-Pleistocene guano may be expected in favorable regions throughout the tropics. If the phenomenon is really as widespread as it would appear to be, it suggests that it must be explained in terms of general planetary changes in precipitation rather than by purely local events. At present it is obviously not possible to go further in interpretation; the work of preparing the present survey will be justified if these tentative results stimulate an interest in what is

now left of the deposits and lead to the recording of information that might bear on the solution of the problem, before such information is irrevocably lost.

PHOSPHATIC DEPOSITS OF ELEVATED ISLANDS

The largest insular deposits occur on the lifted islands of coral rock or with a considerable veneer of coral limestone. They are found irregularly distributed in tropical and subtropical latitudes, the full list of occurrences of this sort being as follows:

Pacific Ocean:

Makatea, with small deposits on Niua, Makahiva, Henderson Island, etc.
Ocean Island and Nauru

Fais

Angaur and Peleliu

Rota, Saipan, Tinian, Aguijan

Kita and Okino Daito Jima

Smaller deposits on the Riu Kiu Islands

Ajawi

Walpole Island

Indian Ocean

Christmas Island

Aldabra (status of other islands obscure)

Caribbean

Navassa

Sombrero

Curaçao

Aruba

Bonaire

The Saldanha Bay and Langebaan Bay deposits in South Africa may well be comparable to these insular localities, and certainly very large deposits due to the phosphatization of igneous rock on the volcanic islands of Redonda, Alta Vela, and Gran Roque may be equivalent chronologically.

Omitting these special cases, the whole of the series listed above have certain common characters.

The phosphate lies in the cavities of a strongly developed Karrenfeld cut in the elevated coral limestone. Where the latter has been analyzed it has been found to be dolomitized. This is certainly the case for Makatea, Ocean Island, Nauru, Kita Daito Jima, and Christmas Island, Indian Ocean. No other cases have been discussed.

Dolomitization of reef limestone occurs unassociated with phosphatic deposits on

Only that some cases of undolomitized elevated reef rock bearing phosphate will be discovered. It can, however, hardly be accidental that the five largest deposits rest on dolomite. Fryer's account of Aldabra indicates strong metamorphism of the reef rock bearing the phosphate which suggests that this locality is also dolomitized. It is impossible to gain any idea of the magnesium content of the reef rock of any of the other localities.

The phosphatic filling of the cavities in the Karrenfeld appears to vary most notably in its iron and aluminum content.

PACIFIC ISLANDS	(Al,Fe) ₂ O ₃	MEAN
Makatea	0.40-0.92%	0.64%
Ocean	0.20-0.70	0.45
Nauru	0.30-0.53	0.40
Imu	1.53-2.17	1.77
Legaur	1.57-2.70	2.05
Bechu	2.22-15.49	8.56
El Malk (nodular)	4.27-18.31	11.29
Enkthapel	13.97-24.40	19.19
Roa	1.12-12.08	6.28
Sipan	1.35-29.67	13.10
Taien	0.86-23.02	13.51
Arujan	no data	18.00
Chino Daito Jima	tr. - 6.08 or higher	3.29
Kita Daito Jima	(mainly aluminum phosphate)	
Yoron Shima	3.87-31.00	11.65
Tori Shima		9.6
Miyako Jima	2.03-18.61	8.16
(excluding cave)		
Hateruma Jima	3.8-9.6	5.71
Walpole Island	no data	19.29

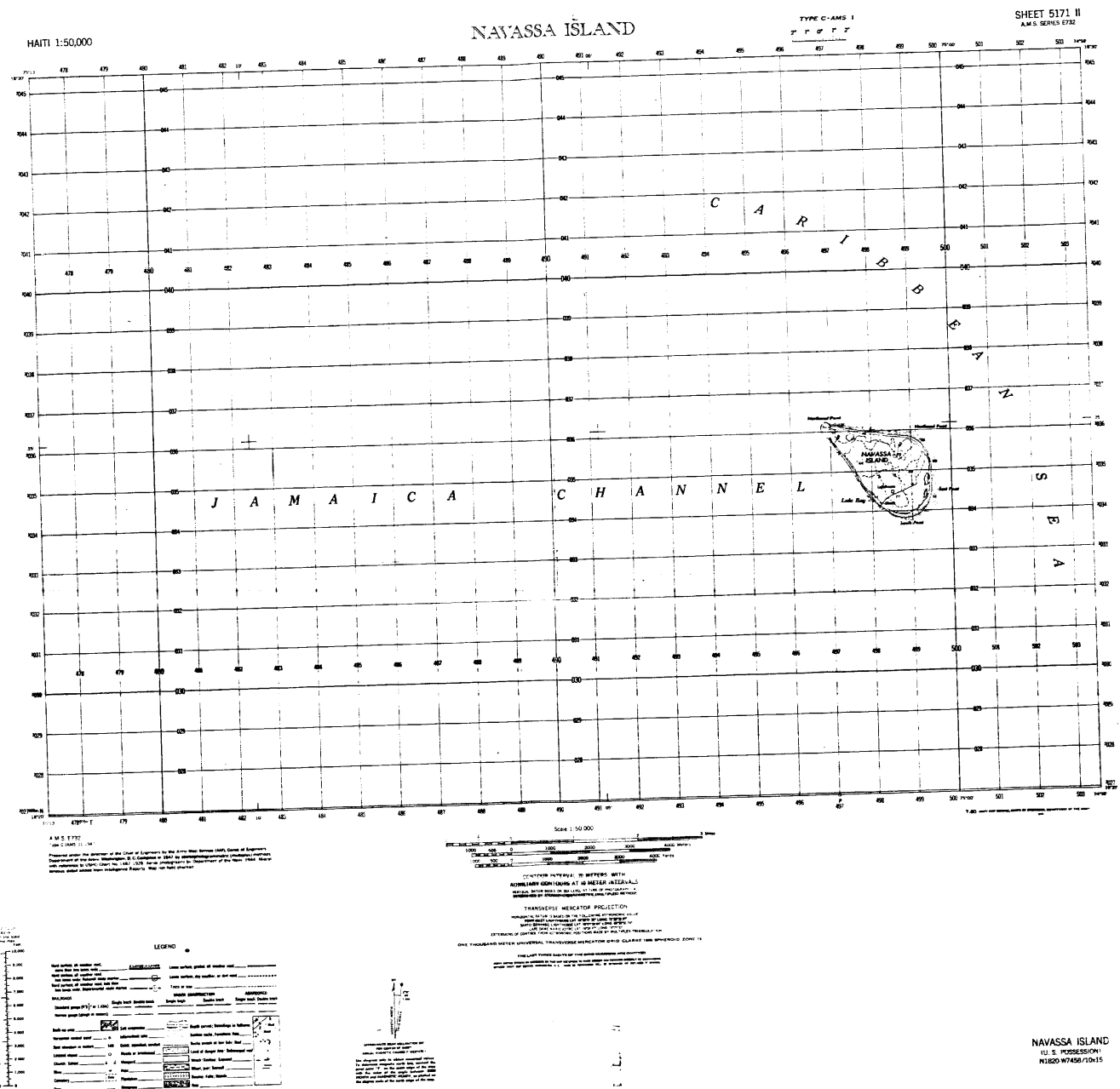
Analyses of the sesquioxides have been given for the underlying dolomitic limestone of two of the extreme cases, namely, for that of Nauru which contains 0.27% to 0.46% (Al,Fe)₂O₃ and for that of Kita Daito Jima which contains 0.08% to 0.78% (Al,Fe)₂O₃. The differences between these limestones, in this respect, is evidently negligible. Excluding that part of Kita Daito Jima that has received pumice from an external source, the spaces of the entire Karrenfeld are filled with a terra rossa-like clay which is presumably the residuum left on solution of the limestone. On Nauru nothing of this kind is found. Makatea and Ocean Island resemble Nauru in this respect. The other

phosphate, and in some cases a typical terra rossa appears to exist. While it is probable that climatic factors and the proximity to rock other than limestone are involved, one factor of considerable importance in explaining the difference between Makatea, Ocean Island, and Nauru on the one hand and the other islands on the other is that these three islands appear to have undergone submergence since the formation of the Karrenfeld. Owen's observation of coral heads attached to pinnacles on Ocean Island is definite evidence in this direction. On Nauru strand lines appear to be cut on pinnacles, and the form of the deposit on Makatea is hard to reconcile with any other hypothesis. The history of these three islands is therefore rather different from that of the Mariana or Daito Islands. Angaur may perhaps have been partially submerged since the Karrenfeld was formed, but this island requires further study.

Outside the Pacific region, Christmas Island appears to have had a history like that of Makatea, Ocean Island, and Nauru, in that residual clay did not accumulate or was not left in the Karrenfeld, but where volcanic rock was exposed to guano solutions it was phosphatized on this island as on others.

In the West Indies, the history of Sombrero is too complex and too inadequately known to make comparison profitable. The upper part of Navassa appears to be comparable to the western Pacific islands. The phosphatic filling of the Karrenfeld on its plateau is rich in sesquioxides, while the deposit in the Karrenfeld of the low terrace around the island is lower in iron and aluminum as if part of the residual filling had been removed by wave action, possibly at a time of slightly higher sea levels than are now prevalent.

The situation at Curaçao is not entirely clear. The phosphate appears to lie on Molengraaf's terrace at 90 to 110 meters. Subsequent to the formation of the terraces by emergence, subsidence to 100 meters is said to have occurred. This may have permitted loss of residual soil, though the Curaçao phosphate is slightly richer in sesquioxides than is that of Makatea, Ocean Island, or Nauru.



Summarizing the above argument, it seems likely that the elevated phosphatic islands can be classified as:

Islands not submerged after the Karrenfeld formations:

Fais
Angaur
Peleliu
Eil Malk
Urukthapel
Rota

Saipan
Tinian
Aguijan
Oldno Daito Jima
Kita Daito Jima
Yoron Shima
Tori Shima
Miyako Jima
Hateruma Jima
Walpole Island
Navassa (in part)

Islands submerged after Karrenfeld formation¹ but prior to phosphatization:

Makatea
Ocean Island
Nauru
Christmas Island
Curaçao and adjacent islands

This difference is of some importance in providing a warning against the assumption of identical history for all such deposits.

Definite information on the age of the phosphate on the elevated islands, or even of that of the underlying limestone, is extremely meager. The dolomite of Makatea is supposedly fossiliferous and was regarded as Tertiary by Agassiz, though nothing critical was published. The Ocean Island dolomite yielded only a single *Carcharodon* tooth to Owen, and from this he deduced a post-Miocene age. Nauru yielded a number of supposedly Tertiary fossils to Elschner, but no detailed report on them seems to have appeared. The deposit on Kita Daito Jima lies on what is probably an early Pleistocene magnesian limestone.

If Tayama's classification of the terraces of the western Pacific islands is correct, the

¹ Rodgers (1948) believes the Karrenfeld forms beneath the soil surface, *pari passu* with phosphatization. All the comparative evidence from islands with exposed, unphosphatized pinnacles (Aldabra, Henderson Island, etc.) is against this view.

Fais, Peleliu, and possibly the Saipan phosphates rest on late Pleistocene raised reef rock or its equivalent. The deposit on Angaur apparently rests on somewhat older limestone. The deposits on Aguijan, Tinian, and Rota appear according to the same scheme to be on Plio-Pleistocene Mariana reef rock, the Rota deposit perhaps on an older part of the Mariana formation than that underlying the other two.

The deposit on Miyako Jima contained an elephant molar, probably of middle or lower Pleistocene age, and rested on a limestone which is probably late Pliocene or early Pleistocene. On the adjacent Tarawa Jima the deposits seem to have lain between Plio-Pleistocene and post-Pleistocene reefs.

The Christmas Island deposit lies on post-Miocene reef. The deposits on Bonaire, Curaçao, and Aruba appear to be Tertiary, though the evidence of a Pleistocene date is not entirely convincing.

The very meager evidence available thus suggests that the bed rock under all these deposits is either Pliocene or Pleistocene. No contradiction arises from the hypothesis that all the immense elevated deposits of phosphate are themselves actually of Pleistocene age, and this is confirmed by the one case of a mammalian fossil found in the phosphate. The evidence, notably from Tayama's work, seems to suggest at least two phases of phosphatization, one in the earlier and one in the later Pleistocene. There is, however, nothing to indicate that each island was not phosphatized at a different time. The periods of phosphatization evidently represent phases of comparatively short duration during the complicated Plio-Pleistocene history of the islands. The Saldanha Bay deposits of barrandite, or some like mineral, are, as has been indicated, probably comparable to the large elevated insular deposits. In this case there is reasonably good evidence for the association of the phosphatization with a Middle Pleistocene high sea level.

In the attempt to elucidate the meaning of these Plio-Pleistocene periods of phosphatization, it is first desirable to ascertain something of the probable rate at which the deposit on the richest islands could have been laid down.

If the area of the phosphatized region of Nauru be taken as 18 km² and the original reserve as 87,500,000 tons containing 38.99% P₂O₅ or 17.02% P, the mean phosphorus deposited on unit area is found to be 82.9 grams per cm². The total quantity of phosphatic guano on Howland Island has been estimated from two apparently independent sources as about 124,000 tons containing 14.9% P. The area of the island is 1.62 km², but it is evident from the existing accounts that not the entire area was phosphatized. If we assume that the phosphatized area was half the area of the island, as seems probable, the amount of phosphorus per unit area is 2.39 grams per cm². This comparison suggests that if the conditions on Nauru were comparable to those on Howland today, it would take about 35 times as long to phosphatize Nauru as was taken to produce the existing deposit on Howland.

The time of the beginning of phosphatization on Howland is uncertain. In its present form the island clearly dates from some post-Pleistocene time. The most recent event in the Pacific Basin that might have influenced phosphate deposition on the drier Line Islands would seem to have been the change responsible for the shift in guano deposition on the South American coast, probably in the first millennium B.C. It is therefore probably safe to conclude that the Howland deposit has been accumulating for at least 2500 years. This would imply a minimum time of 87,500 years to produce the Nauru deposit. It is, however, most unlikely that an island of the size of Nauru could have accumulated its deposit in this time under the existing oceanographic and climatic regime of Howland. The Howland bird colony may have originally covered the whole area within the rampart. The colony on the much larger Malden Island certainly did not. The total guano production from Malden Island seems to have been about four times that of Howland, but its area is approximately 20 times that of the latter island. It is reasonable to suppose that as the size of the island increases the bird colony does not increase proportionately because increase in size of an island will not increase the food available in the adjacent waters within the cruising radius of breeding birds.

If under existing conditions a colony of birds four times that present on Howland represents the upper limit then it would have taken at least

$$\frac{87,500,000}{4 \times 124,000} \approx 490,000 \text{ years}$$

to phosphatize Nauru. This is a very considerable fraction, of the order of magnitude of one-half, of Pleistocene time. Even if the phosphate deposit on Baker Island, which is less well known than that on Howland but may have been three times as great, be taken as a standard, the time of phosphatization would be 160,000 years or about one-sixth of Pleistocene time. In view of the rather critical conditions that have evidently been necessary to produce deposits on atolls of over 100,000 tons during post-Pleistocene time, it is extremely improbable that there would have been time enough during so changeable a period as the Pleistocene for the Nauru deposit to develop under oceanographic and climatic conditions at present represented by Baker and Howland Islands. Such an argument is in accord with the strong impression left by Tayama's results of a complex history, only short sections of which were characterized by intense phosphatization.

If we compare the Nauru deposit with that on the Peruvian islands an entirely different result is obtained.

The present rate of deposition on the best Peruvian sites is 9.6 grams per cm² per year. This material contains 4.59% P, so that 0.44 grams P per cm² per year can apparently be deposited under the most favorable conditions. Assuming no loss the Nauru deposit would at this rate have taken just under 200 years to form. It has, however, already been pointed out that losses did occur from the Peruvian deposits. On North Chincha Island the mean depth of the guano was 12.6 meters. Assuming a density of 0.9 and a phosphorus content of 5.28% this corresponds to 59.9 grams of phosphorus, or just under three-fourths the quantity present per unit area on Nauru. Since the Chincha deposit appears to have taken between 2000 and 3000 years to form, at the same rate the Nauru deposit would have taken about 3000 to 4000 years to form.

Notes and Suggestions

restoration of the Union, with the Constitutional rights guaranteed for all future time."¹⁶
 "repudiation" of his platform was now nearly ready. All that remained to be done was to strike out any word of defeatism,¹⁷ to eliminate "any word in regard to be tortured by any [one] into anything like ignoble to add as a separate paragraph a plank which had been out of the platform as reported by the resolutions come one up the whole document with a "punch" sentence that it might convey an impression of crisp, terse candidate."¹⁸

Lincoln had shifted his ground twice. Starting with an attempt for armistice in any sense, he had adopted the idea of armistice at the risk of disunion. He then took a position which made armistice impossible from the South, yet did not ignore the Northern demand for potential "4". Did he change his attitude to conform with changes of the relative strength of the factions in his party? Was his inability to fathom immediately the dangerous implications of his position? Did he carry over into political life the characteristics which characterized his military career? Or was he changing deliberately in an endeavor to do what he honestly

McClellan, vol. 21, 33353.
 the sentence commencing "We have fought enough to satisfy the two sections" was dropped in the fourth draft, which, from its context, was written earlier than Sept. 6 (McClellan MSS. II., vol. 23, 88959).
 McClellan, no place, no date, McClellan MSS. II., vol. 23, 88986.
 William Adams, pastor of the Madison Square Presbyterian Church, in the context of the letter, Adams had gone over McClellan's letter and that those intercalations in this fourth draft which are not in the Adams's. For example, there is the sentence: "And no peace can be Union." McClellan himself seems to have changed the wording of the sentence as it is clear or even probable that our present adversaries are upon the basis of the Federal Union of the States" to "ready for peace

to McClellan Sept. 9, McClellan MSS. II. This is the sentence in the final letter commencing, "Let me add, what I doubt not was, the sentiment of the convention . . ."
 the sentence "The Union is the one condition of peace—we ask no discovery and had no machinery either for legalizing such claims or

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thought was best for the people of the North? As in so many other cases, the records are silent as to the human aspect of the matter.

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The University of Cincinnati.

NAVASSA: A FORGOTTEN ACQUISITION (1922)

A little known aspect of the expansion of the United States is the acquisition of certain scattered island "appurtenances" which the government has refrained from speaking of as possessions. Even before the Civil War, expansionists sought to extend American rule over non-contiguous territory and made efforts to secure Cuba, the Hawaiian Islands, a naval station in Santo Domingo, Alaska, and a zone across Panama. These ambitious plans failed, but quite incidentally, and almost without public notice, a peculiar, beginning was made in the collection of islands outside our territorial waters.

In the forties and fifties of the last century, large portions of the older agricultural area of the United States showed unmistakable signs of a loss of fertility. The appearance of a new and potent fertilizer, called guano, was hailed therefore as a godsend and demands for it multiplied. The only large supply then exploited was located on certain islands off the coast of Peru where for centuries hosts of birds had been depositing this fertilizer. The Peruvian government found it a constant and convenient source of revenue and sold it only through British or Peruvian agents who charged so high a price and provided so irregular a supply that American farmers became exasperated. The State Department busied itself during the fifties attempting to arrange with Peru, Ecuador, and Venezuela for a cheaper and better marketed supply, but repeated efforts accomplished very little. Adventurous sea captains therefore were encouraged to seek out uninhabited and out of the way islands where birds might have dwelt peacefully for long periods of time. Several of these were reported, but the announcement of efforts to take off guano might lead to complications. As a matter of fact the exploitation of the guano possibilities of a small island, Aves, some three hundred miles off the coast of Venezuela had caused that republic to remember a long forgotten jurisdiction over this far away dot and to drive off the American diggers. The United States had never claimed any islands by right of discovery and had no machinery either for legalizing such claims or

law providing regulations for registering such discoveries at the State Department. The act provided that when any American citizen "may have discovered, or shall hereafter discover, a deposit of guano on any island, rock, or key not within the lawful jurisdiction of any other government, and not occupied by the citizens of any other government, and shall take peaceable possession thereof, and occupy the same, said island, rock or key, may, at the discretion of the President of the United States, be considered as appertaining to the United States". Evidence of the formal act of taking possession and maintaining peaceable possession in the name of the United States was to be filed at the State Department together with a bond to the effect that the discoverers would sell guano only according to rules laid down in the act. When explorers had fulfilled these requirements the island, rock, or key might be proclaimed as appertaining to the United States. Trade with such places was to be regulated as coasting trade between different parts of the United States, the laws relating to acts performed or crimes committed on merchant vessels on the high seas were applied to govern these islands, and the President might use the "land and naval forces of the United States" to protect the rights of the discoverers.¹

Upon the urging of New York and Boston guano speculators, William H. Seward sponsored a bill in Congress which became the law of August 18, 1856. This act provided that when any American citizen "may have discovered, or shall hereafter discover, a deposit of guano on any island, rock, or key not within the lawful jurisdiction of any other government, and not occupied by the citizens of any other government, and shall take peaceable possession thereof, and occupy the same, said island, rock or key, may, at the discretion of the President of the United States, be considered as appertaining to the United States". Evidence of the formal act of taking possession and maintaining peaceable possession in the name of the United States was to be filed at the State Department together with a bond to the effect that the discoverers would sell guano only according to rules laid down in the act. When explorers had fulfilled these requirements the island, rock, or key might be proclaimed as appertaining to the United States. Trade with such places was to be regulated as coasting trade between different parts of the United States, the laws relating to acts performed or crimes committed on merchant vessels on the high seas were applied to govern these islands, and the President might use the "land and naval forces of the United States" to protect the rights of the discoverers.¹

Under the authority of this act, between 1856 and 1885 some seventy islands and groups of islands were recognized as appertaining to the United States. The first two were Baker and Jarvis Islands lying nearly on the equator southwest of the Hawaiian Islands, 0° 15' N. Lat., 176° 30' W. Long., and 0° 21' S. Lat. and 159° 52' W. Long. respectively. They were registered at the State Department on October 28, 1856, though no proclamation was issued by the Secretary until March 2, 1861. Since that time they have been occupied intermittently by American guano diggers, but in 1889 Great Britain took possession of Jarvis without any protest from the State Department. They are designated as American, British, or undetermined possessions on a variety of maps and the United States seemingly has no active interest in them.² It is with the third island to be registered that we are particularly concerned.

¹ U. S. Stat., 112, 120. The details of these negotiations with the Latin American republics and the legislation subsequently enacted are contained in a paper "Latin American Guano Diplomacy" delivered by the author before the Hispanic American Seminar at George Washington University during the summer of 1932. It will appear in the published proceedings of those sessions.

² John B. H. A.

On July 1, 1857, Peter Duncan, a ship captain, discovered that the island of Navassa contained guano. Navassa is a barren, flat, sloped like an oyster shell, about a square mile in area, formed of volcanic lime stone and so filled with holes as to have the appearance of a petrified sponge. It is situated some thirty miles west of Haiti, 18° 10' N. Lat., 75° W. Long., about seventy-five miles east of Jamaica. Captain Duncan found it unoccupied and covered with an amount of guano which he estimated at one million tons. He took possession in the name of the United States and upon his return home assigned his discoverer's rights to Captain E. O. Cooper. The latter and Edward K. Cooper of Baltimore, who seems to have been the business agent, sent John B. Lewis to the island to work the guano deposit and filed formal notice of the discovery at the State Department on December 3, 1857, without supplying either the required certificate of peaceable possession or the bond.³

Cooper had once had a partner in the guano trade, a Jamaican, Ramoth by name, with whom he had broken, as it was later reported, because of Ramoth's inefficiency. The latter had harbored a desire to get even and now saw his chance. He went to Port-au-Prince, suggested to the emperor that the island belonged to Haiti and obtained a lease of the island, contracting to give the government one third of the proceeds of any guano sales. The new leaseholder then went to the governor of Jamaica and told him that Americans were taking Ramoth's guano. The Jamaican executive promptly gave him a letter to the emperor of Haiti supporting a request for a war vessel to protect this Haitian island from American invasion. E. K. Cooper learned of this and hastened to complete the formalities connected with filing evidence in the State Department. He presented an affidavit of peaceful possession which Lewis had made recently and on April 23 warned the Secretary of State that the Haitian government might interfere.

The emperor of Haiti acted early in June and sent two vessels to order the Americans off his island of Navassa. Cooper turned immediately to President Buchanan and Secretary Cass for protection with the result that a frigate was ordered to proceed to the scene. In spite of a second hostile expedition, the Americans stuck to their digging until Commander Turner arrived on the *Saratoga* in August. He found that the visiting officers had attempted nothing violent; nevertheless he deemed it wise to go to Port-au-Prince to give formal notice that the United States would protect American guano diggers under the law of 1856.

³ The papers relating to the discovery and early difficulties regarding Navassa are found in the State Department Archives in vol. V of the series marked "Miscellaneous" referred to as Guano MSS. Some of the

The Haitian government meanwhile had become acquainted with Ramoth's real motives. Under the circumstances the emperor was not disposed to get into trouble with the United States just to satisfy the contractor's revenge and even without Turner's show of force would probably have refrained from violent action. The negro potentate contented himself with filing a protest through the Haitian commercial agent in the United States, B. C. Clark of Boston. The latter claimed Navassa for Haiti on the ground that the island in question had belonged first to Spain and then to France during the colonial era and had been acknowledged to be Haitian when the French recognized the independence of their erstwhile colony.

John Appleton, assistant secretary of state, replied, November 17, 1858, that the department had proof that the island was abandoned and derelict when Duncan discovered it and that the United States intended to protect its citizens in taking guano. Appleton concluded, though, with the statement "the act does not make it obligatory upon the government to retain permanent possession of the island". Sometime later Cooper filed the required bond and on December 8, 1859, Cass at length issued the first guano island proclamation declaring that the required notice of the discovery of guano and the occupation of Navassa in the name of the United States had been filed in the State Department, and that the United States government would protect American citizens in taking guano from the island.⁴ The act of 1856 as interpreted by the State Department was not intended to invest the United States with sovereignty over any of these guano islands⁵ and the proclamation simply stated that the Secretary of State recognized the fact that the island was being occupied in the name of the United States. Presumably the legal status of the island was that of an "appurtenance" rather than a "possession".

Guano continued to be taken from Navassa in the years that followed, principally by the Navassa Phosphate Company and the United States continued to regard the island with an eye which was at least occasionally watchful. When Haiti sought to establish its claim to the island in 1872, Secretary Fish issued an elaborate denial of any such right,⁶ but no

⁴ Appleton's letter is found in the State Department Archives, Domestic Letters, XLIV, 366. The proclamation is found in the State Department Archives, Guano Is. MSS, V, and is printed in part in 137 *U. S. Reports*, 220-221. Other claimants appeared who filed affidavits of discovery for the same island but the State Department ignored them. Their papers are in the Guano Is. MSS, V.

⁵ W. B. Castle, Acting Secretary of State, to the President, 1859.

⁶ Fish to Preston, Dec. 1872. Declassified and Approved For Release 2013/07/29 : CIA-RDP86-00178R000100060011-2

other official attention was given the question by the department. The rather uncertain status of the island was clarified, however, by the courts as the result of a riot. In 1889 some Negro laborers attacked their white bosses, and the superintendent and several of his assistants were killed. At the request of the American consul at Kingston, Jamaica, a British war ship was sent to the island to maintain order and the U. S. S. *Kearsarge* brought the Negroes to Baltimore where they were tried and convicted of murder under the guano act of 1856. Their counsel sought to stay the execution on the grounds that the law of 1856 was unconstitutional, that the island did not appertain to the United States, and that the United States court had no jurisdiction over crimes committed on Navassa. The case passed to the Supreme Court which refused to accept these contentions and decided that "the island of Navassa must be considered as appertaining to the United States".⁷

The last link in the rather submerged chain binding the island to the United States was forged in the twentieth century. Although guano digging ceased during the first decade and Navassa was to all intents abandoned, the State Department did not admit any change in its status. In fact it was not long before this rather moribund interest in the "appurtenance" was revived. As the Panama Canal was approaching completion, Navassa assumed a new importance. The island lay in a direct sea lane from New York to Panama and was the first landfall sighted by ships sailing northward from Panama to New York. Its position made it a menace to shipping and plans were initiated to set up a warning light upon it.

General George W. Gordon, Representative from Tennessee, introduced a bill to erect a light house to serve as a monument to Matthew Fontaine Maury; it was proposed to build this structure on Navassa. In due course a congressional committee stopped to view Navassa and Representative Esch was moved to poetical expression. One of his stanzas expressed his hope:

⁷ The report of *Jones v. U. S.* is in 137 *U. S. Reports*, 202-224. See also a pamphlet *The Navassa Island Riot* (Baltimore, 1889), published by the National Grand Fishermen's Order of Golden Fishermen, to raise money for the defense. During the Cuban revolution Navassa was used as a base by the revolutionaries and in August, 1895, was abandoned for violating U. S. law (*Revised Stat.*, sec. 5286) thereby. In 1898 some Haitians or Dominicans were reported as occupying the island and preventing the agents of the Navassa Phosphate Company from landing. No action was taken, guano digging days were about over, and the company nearly defunct. Even the Haitians abandoned the island. When the Phosphate Company went into the hands of a receiver its rights were

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Notes and Suggestions

Soon may thy reign of terror end
 And welcome lights their rays extend
 To gladden the weary storm-tossed sailor's sight
 On ships that pass by in the night—Navassa.

The proposal to commemorate Maury's services was abandoned after Gordon's death but Congress provided the light. The House, under the influence of a reading of Esch's poetic plea by Adamson of Georgia, inserted the necessary appropriation and the Senate concurred.⁸ The purpose of Congress thus to light more adequately an important approach to the Panama Canal made necessary a public notice to the world. President Wilson proclaimed on January 17, 1916, that whereas the Island of Navassa was then "under the sole and exclusive jurisdiction of the United States and out of the jurisdiction of any other government", and whereas Congress had decided to build a light station thereon, "the said Island of Navassa in the West Indies be and the same is hereby reserved for lighthouse purposes, such reservation being deemed necessary in the public interests, subject to such legislative action as the Congress of the United States may take with respect thereto".⁹

In due time and after great difficulty the light house was erected and since October 21, 1917, has flashed its nightly warning to passing ships.¹⁰ To the general public Navassa is still as obscure as it always has been, but nevertheless it remains the oldest of our islands whether possessions or "appurtenances".

ROY F. NICHOLS.

The University of Pennsylvania.

⁸ *Cong. Rec.*, 63 Cong., 1st sess., 4522; Act of Oct. 22, 1913, 38 U. S. Stat. 124. See also *Cong. Rec.*, 62 Cong., 1st sess., 1063 and House Bill 8895, same session.

⁹ 39 U. S. Stat., 1763. W. R. Castle, Acting Secretary of State, to author, Sept. 1, 1912.

¹⁰ George R. Putnam, An Important New Guide for Shipping, *Nat. Geog. Mag.*, XXXIV, 401. At first the light was tended by several keepers who lived there with their families but so isolated was the spot where mail could be received only two or three times a year that it was difficult to find any one who would take this post. In May, 1929, therefore the light was made automatic and the island is now visited but once a year by a light house tender. At these times the light is thoroughly overhauled and the accretion tanks refilled. G. R. Putnam, Commissioner of Lighthouses, to the author, Oct. 10, 1912.

DOCUMENTS

The Lyons-Seward Treaty of 1862

On April 25, 1862, an Anglo-American treaty concerning the African slave trade was unanimously ratified by the Senate of the United States. Its conclusion accorded well with the general policy of the Lincoln administration. To legislate against the slave trade was an obvious way of conciliating all shades of Republican feeling in the states, without offending the Union Democrats. To conclude with Great Britain a convention of the kind she had so frequently suggested was also a means of eliciting British sympathy for the North. Until the outbreak of the Civil War the United States had always repulsed any proposals involving the search of American vessels by British warships engaged in hunting slavers. She now agreed to permit the practice in certain seas, but the Secretary of State was careful to let it be known that the convention had been "freely offered by this government to Great Britain, not bought or solicited".¹ Seward's statement was apparently confirmed by the treaty papers laid before Congress and Parliament,² and this version of the story has hitherto been unquestioned. Its intentional inaccuracy is, however, revealed by a study of the secret correspondence between Lord Lyons, British minister at Washington, and the British foreign office printed below.³

In the spring of 1861, the American cruiser squadron stationed off West Africa, under the terms of the Webster-Ashburton treaty (1842), had been withdrawn to assist in the Southern blockade. It became more difficult than ever to prevent the slavers, plying between Africa and Cuba, from sheltering under the American flag. As early as May 10, 1861, Secretary Seward told the British minister at Washington that he was willing to make some alternative arrangement for protecting the Stars and Stripes from this abuse. Lord Lyons was instructed

¹ Seward to Perry, U. S. Minister to Spain, Aug. 2, 1862, published on Dec. 1, 1862, 37 Cong., 3 sess., *House Exec. Docs.*, vol. I, no. 1, pt. 1, p. 471.

² 37 Cong., 2 sess., *Sen. Exec. Docs.*, vol. V, no. 57; *Parl. Papers* [Command 3160].

MEMO

TO: R.T. Heiderstadt
FROM: C. Vandrei *CV*
DATE: 8/20/81
RE: Translation of French Article on the History of Navassa Island
cc: G. Strobel, C. Ferris, ~~C. Tronolone~~ NI-287 File

Bibliographic Citation

Montague, Ludwell Lee,
1940 "LaNavase", Revue De La Societe d'Histoire Et Geographie d'Haiti.
pp - 1-24, Volume 12, No. 37. Port Au Prince, Haiti; V. Valcin
Impreur.

The following is a general summary of important points in the article.

This article attempts to relate the controversy over ownership of Navassa to Haitian and Caribbean politics in general. It begins with a discussion of U.S. needs for fertilizer and attempts by the U.S. to negotiate with Peru for rights to guano.

In 1854 an unidentified American discovered deposits of guano on the Isle of Aves (birds) a desert island in the Lesser Antilles. This island is located 147 miles east of Dominique and 300 miles north of Venezuela. The island was occupied by two American companies who began mining the guano. Venezuela claimed that the guano was their property but this was found to be a mistake as an island on the Venezuelan coast has the same name.

Americans in Philadelphia tried to arrange a monopoly through an agency in Caracas by compensating the Venezuela government. However, the American group was in fact expelled by a Venezuelan naval expedition. The U.S. eventually renounced its claim to the island and Venezuela paid \$130,000 compensation to the American company. Venezuela had based its claim on its inheritance of original Spanish claim. This incident led to the eventual passage of the Guano Island Act. This allowed U.S. citizens to claim uninhabited islands for guano mining purposes and authorized the President to use force to enforce these claims. By 1885, 88 islands and groups of islands were occupied under the terms of this act. Navassa is the third in the series.

Guano was discovered on Navassa in July 1857. It was claimed on September 17 and on December 3 the State Department formally announced the claim. Duncan, the original claimant, ceded his rights to guano exploration to Captain E.O. Cooper. By February 1958 Cooper had established a mining operation on Navassa.

Haiti was enforced of the American operation by the French and British Consuls. Haiti claimed the island and sent a naval force to demand that the Americans leave the island, they refused. Cooper appealed to President Buchanan in June 1858. In July the U.S.S. SARATOGA was dispatched to Navassa to protect American interests. The Saratoga arrived in August, but, a direct confrontation was avoided in favor of diplomatic efforts. Haiti protested through Benjamin C. Clarke, their commercial agent in Boston. He cited the basis for Haitian claim as the discovery of the island by Spain and the cession of the area to France in the Treaty of Ryswick. The U.S. replied that, in spite of this the island was abandoned. He also said that the island was used by Haitian fisherman, but, the Americans did not consider this in their response.

It was not until 1872 that the discussion was continued by Stephen Preston, then the Haitian representative in the U.S. He researched Haitian claims and American precedents in similar cases and concluded that the Haitians were entitled to compensation for the fourteen years of American use of the island. He based his argument on the facts used by Clark in 1858 as well as maps of Spanish explorations and the Treaty of Arranjes between France and Spain in 1777. He also cites Charlevoix's 1773 publication as evidence, although Navassa is not mentioned in the book. Preston also referred to the Haitian Constitution of 1805, which mentions territories and islands under Haitian sovereignty. The Haitian Constitution of 1806 only mentions "adjacent islands." Again Navassa is not mentioned specifically.

Preston further argued that the case of Navassa was similar to the case of Cazo Verde (1859) and Alta Vela (1868) in which the U.S. was in illegal possession of guano islands. He also stated that if the Americans could claim uninhabited islands in the Aleutians and the Florida Keys then Haiti has an equal right to establish a valid claim to Navassa. U.S. Secretary of State Fish replied that Preston's arguments substantiated U.S. claims more than Haiti's. He dismissed Preston's arguments as irrelevant.

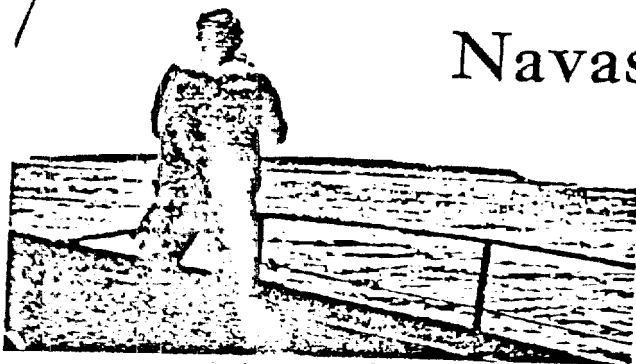
In response, Preston attempted to press his previous arguments further as well as adding affidavits from Haitian fishermen who has used Navassa as early as 1920. Again the U.S. dismissed the Haitian arguments, stating that they accepted Coopers claim and that Cuba and Jamaica could also claim the island if the presence of fishermen could establish ownership.

The article goes on to discuss the involvement of Jamaica in the Navassa controversy as well as the already known activities of the Navassa Phosphate Company. Haiti again became involved when after the employee revolt in 1890 they protested the Supreme Court decision that applied the laws of the United States to Navassa.

Haiti continued to feel a need for revenge. This was fulfilled in 1898 when this island (Navassa) was evacuated for fear of a Spanish attack. The Americans left behind considerable valuable material. Sailing boats from Jamaica, Haiti and Inagur regularly stopped there to obtain items. The loss amounted to 2,500 dollars. The Company recovered 79 dollars at public auction. The remainder of these goods were sold to Admiral Killich of the Haitian Navy for 500 dollars. The goods consisted of provisions, hardware, lumber, tools, 7 boats, a steam engine, 2 mules and 200 to 400 goats. The Company did not survive the loss.

The U.S. retained its rights to Navassa and with the opening of the Panama Canal, the island became a hazard to navigation. Therefore a lighthouse was established there, beginning operations in 1917.

CV/bam
8/24/81



Approaching Navassa from the south.

Navassa Revisited

BY J. ROBERT ESHLEMAN,* W4QCW

IN August of 1954, W4VZQ, WN4HBC and myself put Navassa Island on the air for the first time post war. The island had been represented briefly by K4NI of Navassa Light in the 1920s. Our efforts resulted in some 1300 QSOs, but due to low sunspot activity the results were disappointing. In 1957, another group of teenagers visited the island and made several hundred QSOs during an eight-hour stay. The last legitimate DXpedition to Navassa took place in 1958. In the early 60s the U.S. Coast Guard abruptly altered its policy of permitting amateur visits to the islands. As the years passed Navassa became rarer and rarer until a recent survey by the Geoff Watts DX news sheet listed Navassa as the most wanted country — ahead of Albania and Iraq!

In 1964, a former dental schoolmate, Ernie Hendry, K4CAH, began to make a concerted effort to persuade the Coast Guard to reverse their position. Two years later Frank Harris, WA4HTR, and myself joined in the effort. An unauthorized DXpedition to Navassa that same year only served to strengthen the Coast Guard's resolve to continue to deny permission for visits to the island. The return of Barry Goldwater to the Senate last year renewed hopes that the rigid position of the Coast Guard would be modified. The splendid cooperation of the Coast Guard in making the Heard Island, VK0WR, operation possible also raised hopes of a policy change.

Whatever the reason, the persistent efforts of Ernie, K4CAH, Herb, W4KET, and Lou, *3716 Drakeshire Rd., Richmond, Va. 23234.

W4PJG, were rewarded when Commander H. C. Wyatt sent Ernie a letter in late May informing him that as of June 22, 1969, permission would be granted for small groups to visit Navassa.

Ed Itoller, K4IA, was dispatched to Kingston, Jamaica, to arrange a charter and to carry one of the three beams we would need. A 60-foot twin diesel belonging to Hill's Deepsea Fishery Ltd. was chartered for a five-day period beginning June 21.

Planning

With less than four weeks until our scheduled departure and with the members of the group separated by as much as a thousand miles, planning such a major trip was a big task. Two factors eased this situation greatly. The group kept nightly schedules on 3530 and 7205. Secondly, a group of amateurs in Kingston headed by Chuck Brydges, W4WNZ, were making arrangements for customs and local transport. They also secured most of the food, drink, gasoline and camping gear which our party of twelve would require. By this time ten amateurs, K4CAH, K4FU, K4IA, KV4FZ, W4DQS, W4KET, W4PJG, W4QCW, W4USQ, WA4HTR, and two biologists were committed to make the trip.

On Saturday morning, June 21, nine members of the group and nearly one-half ton of material were assembled at the PAA counter in Miami. Thanks to some previous arrangements made by the Florida gang with PAA, we were only charged eighty dollars in excess baggage. "Never was so much carried by so many for so little!"

Between January and March this year, W4QCW knocked off more than the necessary 500 contacts to become first holder of the new SBDXCC award — and then topped it off by joining a DXpedition. Here's the story of K4IA/KC4.

At Kingston we were met by Chuck Brydges, W4WXXZ, communications officer at the American Embassy, and a contingent of Jamaican amateurs, 6Y5s CB, JR and LA. By the time we had finished our complimentary glass of tropical punch, Chuck had moved our mountain of equipment through customs without a hitch. Minutes later a small motorcade headed for Lloyd's (6Y5LA) place. We changed into our "island" clothes and then split up; several shopping for last-minute items including fresh food and the rest of us going down to Pier Zero to load our gear and supplies aboard the *Miss Jekyll*. She was a 60-foot single diesel fishing boat. The twin-diesel vessel we originally chartered had been captured by the Colombians the preceding week. The significance of the substitution of a single diesel vessel for a twin diesel didn't dawn on most of us until the following morning. Although it appeared that sleeping space would be at a premium for the seven crew members and our party of twelve, there was plenty of extra space in the ship's hold. This extra space was filled with crushed ice, a luxury few DXpeditions of this type experience. With the loading operation finished we all headed uptown for something to eat and to do a little souvenir shopping, leaving Tom and Gene, the University of Florida biologists, aboard to guard our gear.

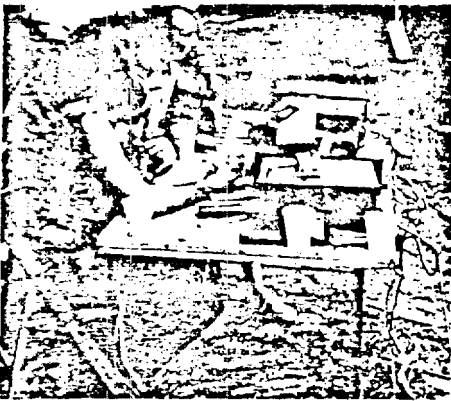
When we returned at 2200 GMT expecting to sail within an hour, Tom greeted us with a long face. During our absence a minor Jamaican immigration official had visited the boat and learned of our trip. He informed Tom that the *Miss Jekyll* was not licensed to carry passengers and we did not have work permits enabling us to go as crew members; therefore, the trip was off. Up until this point everything had gone so smoothly that I could hardly believe I was actually on a DXpedition. Problems just like this had delayed the first Navassa DXpedition for eleven days.

Ernie and Chuck left immediately to try to clear the obstacle. When they still hadn't returned thirty minutes later, Herb, KV4FZ, gave

Dale, W4DQS, five-to-one odds that we wouldn't make the trip. Clearly, this was the low point of the trip. A few minutes later Ernie and Chuck were back with good news; everything had been smoothed over. Instead of leaving immediately the captain delayed us another hour until two more crew members were rounded up. Finally at 2400 GMT Saturday evening we got underway. This should put us within sight of Navassa by sunrise and there by 1100 or 1200 GMT, even if things went slower than expected.

Under Way

When I could still see Jamaican coast six hours underway I began to suspect our arrival time would be somewhat later than expected. By this time about a third of the group was afflicted with seasickness. We were bucking both the wind and the current and progress was antagonizingly slow. The seas were running about ten feet at this point and I knew from past experience a landing at unprotected Lulu Bay would be impossible unless the seas calmed down appreciably. By 1500 we still had not made landfall and the captain decided his estimates of wind and currents were wrong. We changed our course from east to north and churned along for three more hours before Navassa was spotted straight ahead. Fortunately, the swells were only running three to four feet as we cast anchor about 200 yards from the landing. Dale and I, the two Navassa veterans, were accorded the dubious honor of being the first to be sent ashore aboard a very dilapidated looking twelve-foot runabout. About twenty trips were required to transfer our party of twelve plus several tons of supplies ashore. Each of us had to scramble up a wire rope ladder suspended from a catwalk thirty feet above the water. All of our precious equipment and supplies were handlined up to the catwalk by three Jamaicans with unbelievable stamina. Working without gloves in temperatures around 100°, these sturdy fellows brought up every single package without a mishap. Unloading operations lasted from 1930 until after 0100 GMT with



At left, W4PJG (1.) and W4USQ operating the phone positions while at the right, W4KET (1.) and K4IA hold down the c.w. positions.

Ernie in the true tradition of a captain the last one to leave ship and come ashore.

Herb, W4KET, Dale and I had the multiband vertical up and the first station on the air in just over an hour. We opened up on 7205 at 2040 GMT with 6Y5LA followed by WA4WIP our QSL manager. As more fellows came ashore we were able to get two more antennas up, a forty meter inverted vee and a triband three element beam. This gave us three stations for the first night's operation.

When the pile-ups subsided a bit by midmorning Monday, the two cw stations and their antennas were moved about 100 yards to a spot overlooking Lulu Bay. This eliminated about 95 percent of our interference problem especially when we were using cw and ssb on the same band. Antennas at the cw station consisted of a 3-el triband beam on a 25-foot mast, a multiband vertical and a 600-foot long wire across Lulu Bay. At the ssb station we had another 3-element tribander at 25 feet, a 2-element tribander at 25 feet, and separate inverted vees for 40 and 75. With a few exceptions, the cw stations were manned by Ed, K4IA, Hank, K4FU, Dale, W4DQS, and Herb, W4KET. The ssb stations were manned by Ernie, K4CAH, Lou, W4PJG, Bob, W4USQ, and Frank, WA4HTR. Herb, KV4FZ, and I were designated as multimode operators and put in time at both locations.

Monday afternoon the USCG *Hollyhock* pulled into Lulu Bay and sent a party ashore. Although our beer supply was dwindling rapidly, Ernie decided to offer cold beer to every crew member who came ashore with the hope that this would assure Coast Guard cooperation for future DX-peditions to Navassa. Later that evening a grateful crew sent us two gallons of chocolate ice cream.

In many respects Monday was our big day. We had a four-hour, ten-meter opening to the States which produced hundreds of QSOs. Herb, KV4FZ, made the first 160-meter QSOs ever recorded from Navassa, and the 80-meter stations were solidly activated. Sunday night 80



We entrusted our lives to this little boat without realizing that the transom was practically rotted out! The little runabout fell apart as we loaded her aboard ship for the trip home.

cw was tried briefly with the vertical but was given up due to our extremely poor signal. On 75-meter ssb I was able to hit QSO rates as high as 40 per hour with a barefoot transceiver and an inverted vee with the apex at only 20 feet. Numerous west coast stations, as well as ON4UN and GI3OQR, were worked on 75. Our only serious mishap occurred Monday afternoon when Ernie slipped and fell into a rocky crevice while erecting a forty-meter antenna. Fortunately, our medical kit contained some pain killers and muscle relaxants and we were able to make our patient reasonably comfortable. A well-equipped medical kit saved the DXpedition from possible cancellation after less than 24 hours operation.

Tuesday morning the captain of the *Hollyhock* and several crew members came ashore to finish the maintenance on the lighthouse. Ernie, Lou and I were permitted to climb the lighthouse with several members of the crew. Unfortunately there was no possibility of using this magnificent 140-foot mast as an antenna support. There is over one-half mile of steep rugged terrain between the landing and the lighthouse and besides permission could not be obtained for its use. The CG men departed around midmorning. Three hours later I was surprised to see the *Hollyhock* sailing back and forth along the south side of the island. At 1900 GMT a telegram was delivered to Ernie from the 7th District CG in Miami and he was requested to accompany the crew back to the *Hollyhock*. Without our knowledge several of the Jamaicans had captured some goats and taken them aboard the *Miss Jekyll*. The Jamaicans were required to give up their hard-earned prize. We felt sorry for the poor Jamaicans and we were also concerned that the incident might mar the excellent amateur-Coast Guard relations which had existed up to this point.

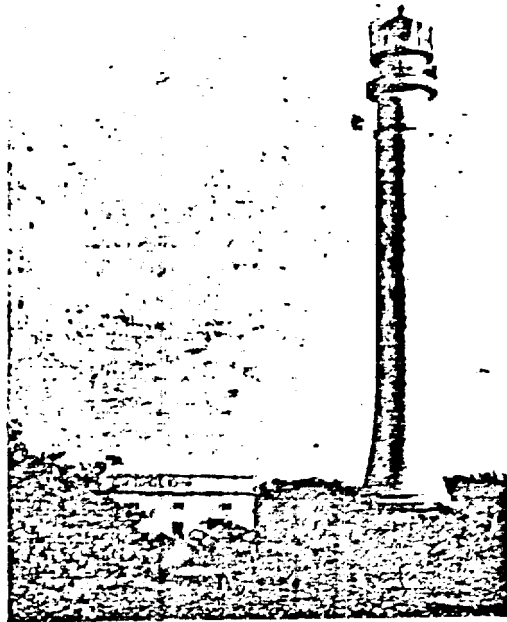
Tuesday night was very productive on all bands with the exception of ten meters, but Wednesday morning found us begging for contacts. Ten meters was flat and fifteen was not much better. Ernie polled the group on their wishes for a departure time. Should we tear down Wednesday afternoon and aim to get underway by dusk or should we tear down early Thursday morning hoping to make Kingston before midnight? The temptation of a soft bed and some good food was too much — the vote was eight to two in favor of leaving.

The really hard work of reloading was once again handled by the Jamaicans, who handlined all our equipment and supplies from the catwalk to the runabout thirty feet below. Ernie kept the last station on 15-meter ssb until 2000, when it too had to be dismantled. Four hours later we hauled anchor and headed for Kingston. The return trip took only thirteen hours. Apparently Jamaica is a slightly easier target than Navassa! The climax to the whole affair took place in a little Chinese restaurant in Kingston Thursday night where the K4IA/KC4 gang plus W4WXZ, 6Y5DW, 6Y5JR, 6Y5LA and 6Y5SR drank numerous toasts and consumed mountains of food.

Having been on several previous DXpeditions and having knowledge of numerous other operations, I frankly wondered at the outset how ten fellows could make such a trip and return as friends. Surely someone would hog the stations or be generally obnoxious. Certainly we did experience minor tensions and disagreements, but the fact that Ernie, K4CAH, had been clearly designated as the leader of the group prevented any of these incidents from becoming major blowups. Future multioperator DXpeditions would do well to make note of this fact.

The 11,162 QSOs made in under 72 hours operation must certainly be a record for a DXpedition of such short duration, if not for all DXpeditions. The tremendous demand for QSOs on bands other than 20 meters can be at least partly attributed to interest in the new 5BDXCC award. Once again the savvy of the average DXer was demonstrated. QSO rates of 100-150/hour were not uncommon. Directional calls were honored and no difficulty was experienced in keeping schedules with hometown stations.

In closing I would especially like to thank Herb Reaves, W4KET, and Frank Harris, WA4HTR, for assistance in the preparation of this story. Q57



The Navassa lighthouse was built in 1915.

K4NI Navassa Island—1928

BY RUSSELL DUNAJA,* W3BBF

In January 1928 the Radiomarine Corp. of America called me and offered me a job as Radio Operator aboard the SS *Catherine* of the Bull Insular Line in San Juan, P.R. The ship carried passengers and freight between San Juan, Santo Domingo, and St. Thomas, Fredrickstad and Christianstad in the Virgin Islands. I was taken to Puerto Rico as passenger on one of the Bull Insular line freighters, and passage was guaranteed back to the U.S.A. On arrival at San Juan, P.R. I found that I was 2nd Operator and A. J. Croner was First Operator.

After about four months on the inter-island run, we both got tired of it and noticing on the bulletin board at the San Juan Post Office openings as Radio Operators and Lighthouse Keepers at Navassa Island, 9th US Lighthouse District, we both applied, passed the examination and were shipped to Navassa Island aboard the Lighthouse Tender *Acacia*. Before I left, I had one of the radio operators on one of the freight ships buy me a 32-20 Savage rifle and 1000 rounds of ammunition and I sent home for my 12-gauge double-barrel shot gun and 22 cal. rifle, as there were wild goats and wild pigeons and doves on the island. I also brought along my experimental radio gear that I was testing on

board the *Catherine* (mostly superregenerative receivers).

On arrival, we were hoisted out of the cargo boat in a cargo sling and found the island was in two levels. The first level was about 25 feet above the sea and a narrow-gauge railway ran to the next level and the push cars were pulled up the steep incline by a winch and steel cable and a Bull Dog gas engine. The next level ran to the dwelling and lighthouse. I guess the length of the railway was about 2½ to 3 miles.

The island was mostly limestone rock with the holes filled with guano which in the 1800s was shipped as fertilizer to Baltimore in sailboats. There were thousands of booby birds nesting in the trees. The island was covered with wild palm and wild fig trees and also a poisonous tree similar to sumac. Near the lighthouse were several papaya trees with delicious fruit and also wild limes. There were also wild peppers which were hot enough to burn your insides out. Of course, we had to try out our rifles and shot several wild goats and pigeons. The goats were stuffed with garlic to kill the wild taste and roasted and didn't taste too bad. There was a boat with supplies at the island every three months and we ordered our supplies to last six months. Most of the food was dried fruit and vegetables also canned food and smoked meats

* 7524 Battle Grove Circle, Baltimore, Maryland 21222.



The Author (1928)

as we had no refrigeration. The fishing also was very good and we caught red snappers, small barracudas, and several other tropical fish. I also caught land crabs at night when they came out of their holes to eat grass. These were put in a box for several days and fed potato peelings to get rid of the grass taste. They were boiled in salt water and didn't taste bad. At night the crabs would crawl into the house and had to be swept out in the morning.

A. J. Croner left after a few months as he caught a rash similar to poison ivy. Two other Puerto Rican keepers were on the island with me and one of them had some chickens. After the feed was gone, the chickens had to eat cockroaches (about 1½" long) and scorpions and other bugs. (No more chicken for me!) The power supply here was a 110 Vdc Delco plant with storage batteries and also a Bull Dog gas engine belted to a 4 kW 110 Vdc generator. The transmitter was a 2 kW Navy Standard quenched spark set with a 500-cycle motor generator. The antenna was a "L" type flat top 4-wire from the 160-foot lighthouse tower to a 60-foot telephone pole. The receiver was a Navy Standard with 2 stages of audio. The frequencies were 355 kc. and 500 kc. and with heavy static NAW Guantanamo Bay, Cuba, could not be worked. Our call was WVEA and later WSZ.

About this time the UX 222 screen grid tube came out and one was ordered. A tin cracker box with a hinged top was used and a shield partition was soldered in. The coils were wound on old tube bases. The detector was a UV 199 with the UX 222 rf Stage. This was hooked up to the two-stage audio amplifier. All kinds of SW broadcast

stations were picked up so the coils were trimmed to 14 Mc band and stations all over the world were heard. The next thing was get permission to put up the amateur station and the call K4NI was received. An 852 was ordered and also a Cardwell 500µF transmitting condenser. With plenty of 3/8-inch copper tubing on hand a high-C Hartley coil was wound. A 12V storage battery was used for the filament and a 3000-v. tap was taken off the spark transformer (Spare transformer). The antenna was an 80-meter Zepp from the top of the tower to a 60-foot telephone pole. The spreaders for the feeders were wood boiled in beeswax. The power was 500 cycles ac but due to the high-C circuit the wave was not too broad. Hundreds of amateurs all over the world were worked and a schedule was kept with NKF at Washington, D. C. Tests with NKF were run and wavelength was lowered until we were on 13 meters which was as low as the transmitter would go (capacitor all the way out). Later, tests with an SM station was tried and it was possible to work him with only a 45V "B" battery for plate supply. That changed me to dc and I sent home for my surplus aircraft dynamotor (1500V, 233mA), which was belted to the big MG set and I went on the air with pure dc.

I had to keep light watch every third night and this gave me plenty of time to operate. Also I had to take weather observations and send them to NAW Guantanamo Bay on 355 kc spark (about 90 miles away). I had a postcard size Kodak with me and took a lot of pictures of the island. The QSL card was a picture of the lighthouse with the call K4NI on it, but I soon ran out of cards and a lot of stations didn't get QSLs.

The light was kerosene gas with gas mantles and was turned by weights which had to be wound up about twice a night. The groceries came from the commissary at Guantanamo Bay and it cost us about 10 to 15 dollars a month to live. The water supply was rain water which was caught in a cistern. We received our mail every three months when the supply boat arrived. I was to stay on the island 9 months and then get 3 months leave with pay, but as a new automatic light was installed using acetelene gas I was asked to stay 18 months with 6 months leave with pay. So in 1929 K4NI was dismantled. The 2-kW spark was surveyed by the Navy and dumped overboard. The 500-cycle MG set and the Delco plant were removed from the island. We were taken back to San Juan, P.R.

We were the last lighthouse keepers on Navassa Island, as the light was now entirely automatic. After a few weeks in Puerto Rico I took passage to Baltimore, Md. and later got transferred to Lightships 5th Lighthouse District Baltimore, Md. as Radio Operator. I wish to thank the hundreds of amateur radio operators that made the stay on the island a pleasure and also am sorry I could not QSL 100%. It was a lonely life with only 3 of us on this island only about 8 miles square. Without amateur radio I would not have stayed. [QST]

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THE GEOLOGY OF NAVASSA ISLAND

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ABSTRACT: Navassa Island shows two erosional raised terrace levels at about 20m and 60m which are tilted to the north west. The main rocks are Eocene shelf limestones. These have suffered some solution and are covered by a diagenetic crust, accretionary palaeosols, and red-brown pisolitic deposits in which the pisolith nuclei are composed of volcanic ash fragments. It is concluded that Navassa is not an atoll, as has been suggested, but instead is an uplifted fragment of an Eocene shelf which may have extended as far east as Haiti.

INTRODUCTION

NAVASSA Island (Lat. 18°24'N. Long. 75°01'W.) lies in the Jamaica Passage, between the islands of Jamaica and Hispaniola. It rests on a submarine ridge, of 700 metres average depth, which forms an extension of the Haitian Peninsula de la Hotte.

The island is, by tradition, Haitian, but has been effectively controlled by the U.S.A. since the discovery of commercial phosphate deposits by an American citizen in 1857. The sovereignty of the island is still a matter of discussion. It has been uninhabited since the lighthouse was rendered fully automatic after World War 2, but was formerly the home of phosphate miners and coastguards.

The only available account of the geology of Navassa is based on samples and descriptions obtained during a visit by

G. R. Procter, a botanist from Jamaica (appendices by L. J. Chubb, and D. J. Burns, H. R. Versey and J. B. Williams to Procter 1959).

This paper outlines the results of a brief geological investigation of the Island made possible by a visit from H.M.S. HECLA in 1972, during a geological investigation of the Jamaica passage sponsored by C.I.C.A.R.

MORPHOLOGY

The best available map of the Island is the U.S. ESSA chart CGS 953, and notes on the topography of Navassa and the nature of the surrounding sea are given in the "West Indies Pilot," (MacFarlane, 1933). This information has been supplemented by our observations, and by the results of an aerial survey carried out by a helicopter from H.M.S. HECLA.

The island is pear shaped (Fig. 1), with a long diameter of 3.5 km. Two well defined terrace levels give it a striking profile (Fig. 2). The highest, varying from 45 to

77 m forms a central, north westerly tilted plateau which covers most of the Island's area. This terrace has a slightly raised rim, and shows a hummocky topography, with low limestone ridges a few metres high being separated by soil filled hollows, small vertical sink holes, some up to 6 m across and 5 m deep were common in parts of this surface. The plateau is surrounded by an escarpment which falls sharply to the lower, fringing terrace level. This escarpment is steep and rubbly, with craggy cliffs on its upper part around the southern and eastern coastlines. No notches or sea caves were observed at the base of this feature, but it was not possible to walk the entire length of the cliff in the time available. This cliff falls directly into the sea at the north western point of the island, but everywhere else it is fringed by a lower terrace, averaging 100 m in width, at some 20 m above sea level. This terrace also shows a north westerly tilt, with a height differential of some 10 m between its extreme ends. It is truncated by steep to overhanging coastal cliffs, deeply notched at sea level. The sea at the foot of these cliffs is deep (Fig. 1) and there are no well developed shoaling reef structures, except perhaps at the north west of the island. There are no beaches, and access is gained by climbing a steel rope ladder which is to be found suspended from an overhanging crag in Lulu bay (MacFarlane 1933). Bathymetric surveys of the sea floor around Navassa indicate that a submerged terrace, with an average depth of 36 m, extends for about 1 km offshore.

LITHOLOGIES

The rocks of Navassa Island fall into two groups. The first is composed of marine limestones which constitute most of the island, and which are overlain by the second group which consists of a variety of crust and accretionary soils.

The dense, pure limestone is especially rich in algal remains, with small masses of encrusting coralline algae being particularly common. Massive corals are found at various places in the limestone,

but nowhere is there evidence of extensive reef development. Molluscs are generally found only as casts and moulds, and the remains of foraminifera and bryozoa are scattered throughout the lithology. Thin sections of the limestones show that the structure of the originally high Mg-calcite particles (coralline algae and foraminifera) is generally recognisable, although they have probably suffered incongruent dissolution. The mollusc fragments (originally aragonitic) have suffered extensive dissolution. Precipitation of a spar cement was followed by the growth of an opaque mineral lining remaining cavities.

Burns, Versey, and Williams (in Procter 1959) identified the coral *Montastrea annularis* in the Navassa Island samples, for which they quoted an age span of Pliocene-Recent. In the same work, Versey compared the micro-facies of the Navassa limestones with that of the Coastal Group of Jamaica. He identified the foraminifera *Operculinoides* and *Heterostegina*, and concluded that the age of the limestone lay in the range Miocene-Recent. Shallow water benthonic foraminifera from our collections include *Amphistigena cubensis*, Palmer and *Dorothea* sp. The common massive coral of these limestones has been identified as *Astrocoenia* sp., a form easily mistaken for *Montastrea annularis* in recrystallised material. This faunal assemblage indicates that at least some of the limestones are older than was thought previously, and are of Eocene age. Similar algae rich limestones occur in the Lower Middle Eocene succession of north eastern Jamaica.

The environment of deposition of these sediments was most probably and open agitated shallow shelf with patchy development of coral growth.

A search of the terrace surfaces failed to reveal any evidence of the existence of a Pleistocene platform encrusting facies which might have been expected to have developed along with the erosion of a marine terrace.

The Karst surface of the limestone terraces is generally coated by a dense laminated calcite crust of varying thickness which also penetrates fissures and lines

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solution hollows. This crust may correspond to the dense crust referred to by Multer & Hoffmeister (1968), but there is no clear evidence that it formed beneath a soil. Small brecciated horizons occur within some of these crusts, indicating penecontemporaneous fragmentation and recementation of this material.

Reddish deposits may overlie this crust, as well as filling irregular cavities in the limestone surface, and penetrating along joints and other fissures. These deposits are of two types. The first is massive and brick-like and may be traversed by a network of paler tubes, which presumably represent root moulds. This is interpreted to be an accretionary palaeosol. The second consists of red brown or purple pisoliths of up to 2 mm diameter. On the lower terrace this material is cemented by calcite, on the higher terrace the pisoliths are unconsolidated, and have accumulated in hollows. Burns, Versey and Williams quote chemical analyses for this material (in Procter 1959) which indicate that it is rich in calcium and alumina, and contains between 1% and 7% phosphate, and, while pointing out affinities with the mineral Sokolovite, concluded that it was made up of a number of minerals collectively rich in calcium and alumina. Examination of calcite cemented pisolitic material from our collection shows that the pisoliths have nuclei of volcanic glass fragments which in turn contain small crystals of feldspar. The pisoliths have formed by the concentric accretion of an optically undeterminable red-brown mineraloid about these nuclei. Some pisoliths are fractured, and the fractures filled by fibrous crystals showing straight extinction. The presence of volcanic ash as nuclei for the pisoliths would help to explain some of the problems of their chemistry. These pisolitic materials presumably result from the accumulation of volcanic ash on the limestone surface, and the sub-aerial precipitation of mineraloids around the ash particles.

STRUCTURE

The only structures detected in the

massive limestones were faults and joints. On the south coast a small east-west trending normal fault was seen displacing the terrace surface southwards by just over a metre. Unfortunately no detailed measurement of these features was possible in the time available.

GEOLOGICAL HISTORY

The Eocene limestone of Navassa Island was laid down in a shallow tropical open shelf area, with scattered development of coral heads, and no supply of terrigenous sediments. After the lithification and early jointing of these limestones, relative movements of Navassa and the surrounding sea level produced two erosive terrace levels, at about 20 m, and 60 m, as well as some levels now submerged. Solution of the terrace surface was succeeded by the accumulation of volcanic ash on the island's surface. Finally, faulting occurred, displacing the terrace surface. At some stage after the formation of the terraces the island became tilted to the north west. It is not possible to date either the terrace formation or the tilting with the information at our disposal.

DISCUSSION

Chubb has demonstrated the many similarities between Navassa Island and certain Pacific Islands, including Nauru, which are uplifted atolls (in Procter 1959).

Although the upper terrace of Navassa does have a slight rim, we were unable to detect any facies variation in the limestones that would support the suggestion that they had been deposited as an atoll. They all indicated deposition on an open shelf.

A preliminary study of gravity and magnetic data in the region of Navassa fails to reveal any marked anomaly that might be expected if Navassa were an atoll founded on an old volcanic cone. Instead, the bathymetry of the region shows that Navassa rises from a submarine ridge which extends westwards to the Massif de la Hotte. It is possible that the limestones of Navassa island were laid down on a shelf

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which stretched eastwards to Haiti. They were clearly not formed on an atoll.

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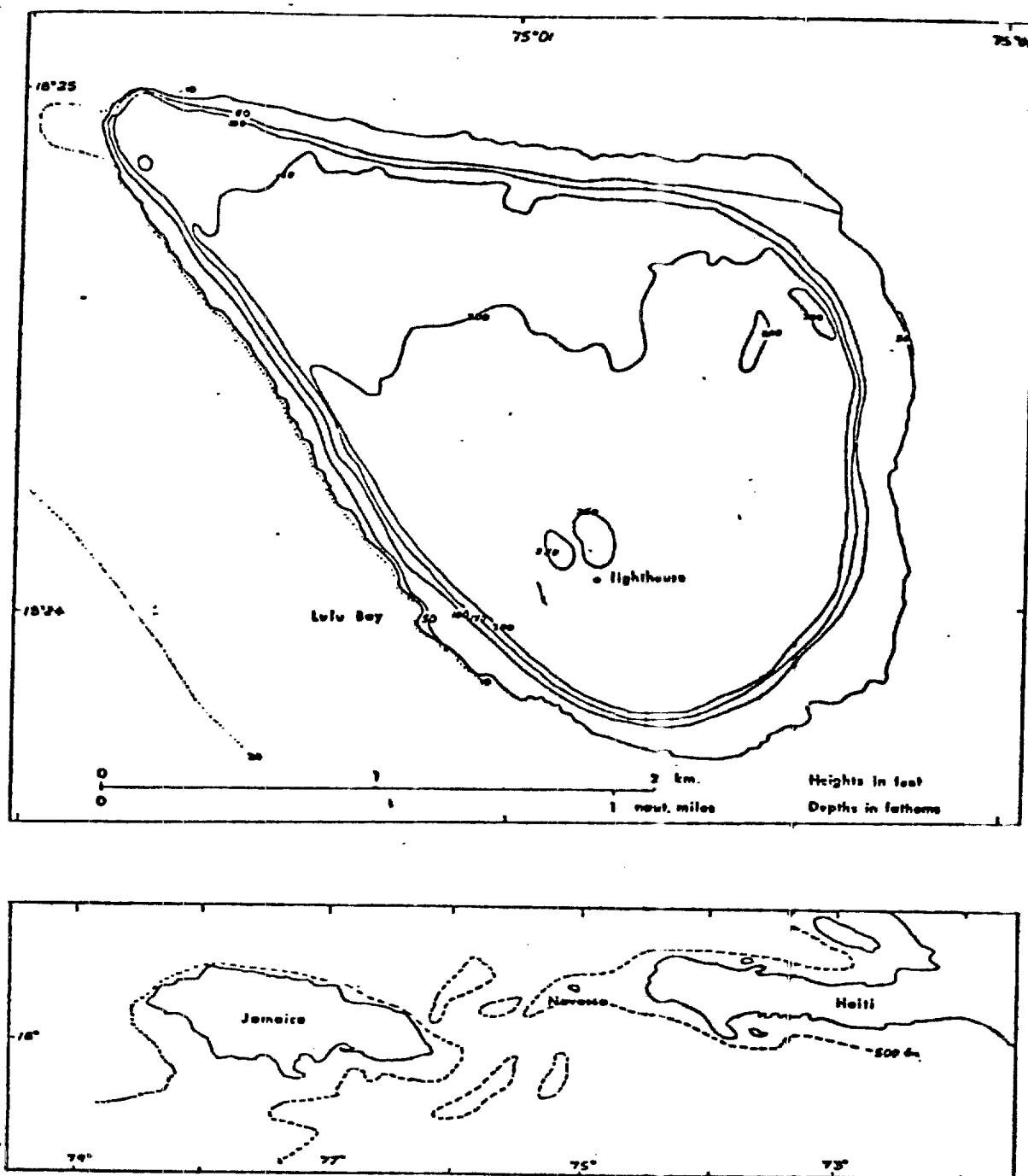


FIG. 1. Navassa Island based on US and British charts and miscellaneous information.
1 fm = 1.8 m.

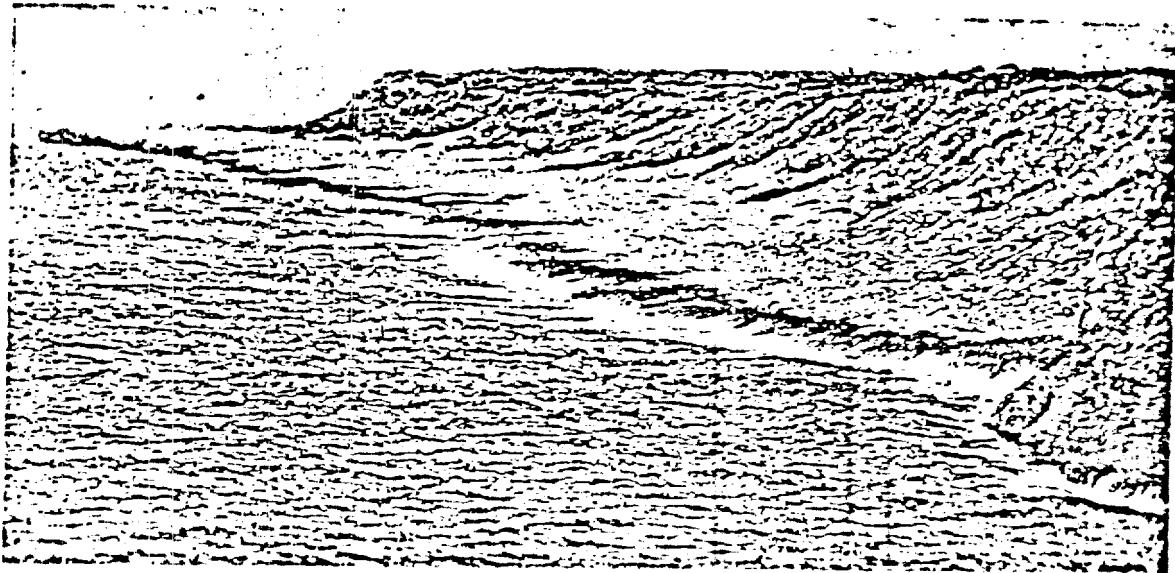


FIG. 2. Oblique aerial photograph of the north coast of Navassa Island. The sheer cliff of North West Point is at the right. The tilt is visible on the lower terrace

COLOR NEGATIVES
NAUASSA Island

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NAUASSA Island